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Jeffrey B. Mullan
MassDOT Secretary and CEO
and MPO Chairman

Arnold J. Soolman
Director, MPO Staff

MEMORANDUM

DATE May 20, 2010

TO Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization

FROM Arnold J. Soolman, CTPS Director

RE Work Program for: HOV Lane and I-93 Access Improvements in the South Bay/Savin Hill Area

ACTION REQUIRED

Review and approval

PROPOSED MOTION

That the Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization vote to approve the work program for HOV Lane and I-93 Access Improvements in the South Bay/Savin Hill Area in the form of the draft dated May 20, 2010.

PROJECT IDENTIFICATION

Unified Planning Work Program Classification

Planning Studies

CTPS Project Number

22122

Client

Boston Metropolitan Planning Organization

CTPS Project Supervisors

Principal: Karl Quackenbush
Manager: William Kuttner

Funding

MassDOT FTA §5303 Transit Planning Contract #80-0004;
MassDOT 3C PL Highway Planning Contract #59796

IMPACT ON MPO WORK

This is MPO work and will be carried out in conformance with the priorities established by the MPO.

BACKGROUND

The Southeast Expressway portion of I-93 is a key north-south link in the regional expressway system, with individual sections handling as many as 250,000 vehicles per day. Between Braintree and Massachusetts Avenue in Boston there are eight travel lanes. Since 1995, capacity of the Southeast Expressway has been effectively enhanced by the use of a reversible high-occupancy-vehicle (HOV) lane, known as the "zipper lane," reflecting the process of opening and closing its northbound and southbound components over the course of each weekday.

The zipper lane operates between Braintree and Savin Hill, and allows five lanes of northbound traffic during the AM peak period, and five lanes of southbound traffic during the PM peak period. While the zipper lane is in operation, the off-peak direction has only three lanes available. During the midday period and at night, four travel lanes are available in each direction. Eligibility for zipper lane use is currently set at 2+ occupants.

Because of the right-of-way (ROW) requirements to implement the zipper lane, the northern terminus of this facility was placed just south of Savin Hill, about a mile south of Columbia Road. For over two miles north of the zipper facility, the Southeast Expressway operates as a conventional eight-lane expressway, with four lanes in each direction. These four-lane northbound and southbound sections act as bottlenecks and cause traffic queues, congestion, and delay every weekday.

At Massachusetts Avenue, the Southeast Expressway meets a newly constructed Central Artery/Tunnel (CA/T) Project expressway segment with greater capacity in both directions including a pair of newly built HOV lanes, available to vehicles with 2+ occupancy at all times. Connecting the zipper lane HOV facility with the CA/T HOV lanes has long been viewed as desirable for two reasons:

- Adding capacity in the peak direction would reduce congestion.
- Buses and other HOVs would receive much greater benefit than they do now.

During the recent reconstruction of the Central Artery, a number of different ramp configurations were used to enter or exit the Southeast Expressway in the vicinity of the project's southern limit. During one phase of construction, there was an additional southbound on-ramp at the Massachusetts Avenue connector. While this on-ramp was not part of the final project design, it exhibited certain traffic flow benefits while it was in operation, and interest in restoring it or adding a comparable ramp is ongoing.

Adding an HOV facility in the gap between the northern terminus of the zipper lane and the CA/T HOV lanes would require widening the Southeast Expressway. Some of this widening may be able to be accommodated within the existing highway ROW. It is certain, however, that adjacent land now used by private owners or other government agencies would need to be incorporated into an expanded Southeast Expressway corridor.

During the planning of the CA/T project there was some consideration of extending the project limits to the south and adding a frontage road system. These plans, as well as other potential modifications of the arterial road system in the study area, will be reviewed, and promising approaches may be cited as part of this study.

At Savin Hill it is highly likely that this study will determine that part of an MBTA rail corridor would be needed in order to accommodate an HOV lane extension. This would in turn require the MBTA to extensively rebuild and perhaps bury one or more tracks in that corridor. If such a reconstruction were undertaken, an opportunity of adding a second track for a portion of the Old Colony commuter rail line would open up.

OBJECTIVES

The principal objectives of this work program are:

1. To identify and describe one or more feasible options for implementing a new HOV lane connecting the existing Southeast Expressway HOV facilities.

2. To identify options in the South Bay area for adding a southbound entry ramp to the Southeast Expressway, especially in conjunction with the construction of a new HOV facility.

3. To identify likely land takings and major construction efforts that would be required to implement the HOV and entry ramp improvements.

4. To analyze the potential for commuter rail capacity improvements that might be achieved in conjunction with the construction of a new HOV facility.

5. To gather and organize documents and other materials which can be used, along with this study's products, in support of further planning and design efforts.

WORK DESCRIPTION

The work required to accomplish the study objectives has been grouped into six tasks:

Task 1 Gather Right-of-Way (ROW) and Traffic Data

Peak period traffic volumes and travel speeds will be updated as required for all relevant travel lanes and ramps. Available roadway and transit plans, profiles, and ownership boundaries will be obtained from MassDOT operating agencies or the City of Boston.

Product of Task 1

Collection of readily available roadway, land use, traffic, and operations information

Task 2 Develop an HOV Extension Strategy

Implementing a new HOV lane in the study area would require expanding the Southeast Expressway ROW. The location and extent of required land takings will be directly related to design issues such as the location of HOV lane entries and exits as well as standards regarding lane width and separation barriers. The information gathered in Task 1 will be used to define a general design for a new HOV facility. Industry literature and consultation with agency personnel will be utilized to develop a conceptual plan that adheres to safety and operational requirements.

Product of Task 2

Conceptual plan for design and operation of a new HOV facility

Task 3 Identify a Second Southbound On-Ramp Option in the South Bay Area

While adding a second southbound on-ramp is not strictly contingent on extending the HOV lane, the land takings required to extend the HOV lane will influence or even determine the design and location of the second ramp. Adding the ramp itself may require further land takings and possible reconfiguration of the frontage and other local roads. A manual local-area traffic assignment as well as a spot operations analysis may be required as part of this task.

Product of Task 3

Conceptual plan for a new southbound on-ramp to the Southeast Expressway

Task 4 Identify Possible Rail Improvements

At this point this study assumes that expanding the Southeast Expressway corridor at Savin Hill will require the incorporation of land that is currently part of the MBTA Red Line/Old Colony Line rail corridor. The required reconstruction of the various MBTA rail lines, and perhaps even the Savin Hill station, would likely be one of the most expensive aspects of building the envisioned HOV lane extension.

It is possible, however, that this investment could complement long-range MBTA capital plans. For instance, rebuilding the rail corridor so some tracks are underground, with other tracks at grade above, would present an opportunity to add a second track to the mostly single-track Old Colony line. The extent and usefulness of such a plan will be considered in consultation with MBTA staff and with reference to past engineering studies.

Also, throughout the MBTA system major infrastructure elements are approaching the end of their design lives and major reconstruction is an appropriate investment in its own right. Accommodation of the HOV lane extension might be envisioned as part of an ongoing capital program.

Product of Task 4

Conceptual strategies for improving and reconfiguring the MBTA rail corridor

Task 5 Prepare Compilation of Materials on Existing Conditions

The materials gathered in Task 1 will allow the planning in Tasks 2, 3, and 4 to proceed. Task 5 will put the collected materials into a form in which they are useful as a planning resource going forward. Freestanding publications will need to be catalogued and synopsized in a bibliography, and field notes will need to be incorporated into memoranda as appropriate.

It is not known at this time what formats the maps and technical materials available at the operating agencies are in. CTPS technical resources will be used to put these materials into electronic formats most useful for this and subsequent studies.

Product of Task 5

Compilation of materials on existing conditions

Task 6 Document Possible Improvements

It is anticipated that because of the severe constraints in this corridor there will be one basic HOV strategy, perhaps with some minor variants. This HOV alternative will be described and analyzed using the available technical resources, as will a proposed southbound on-ramp. Input and comment from professionals both inside and outside of the agencies will be sought. Required land takings will be highlighted.

A range of potential improvements to the commuter rail corridor will be described. These analyses will be very preliminary, but they will utilize input from Rail Operations.

Product of Task 6

Memorandum describing possible improvements

ESTIMATED SCHEDULE

It is estimated that this project will be completed five months after the notice to proceed is received. The proposed schedule, by task, is shown in Exhibit 1.

ESTIMATED COST

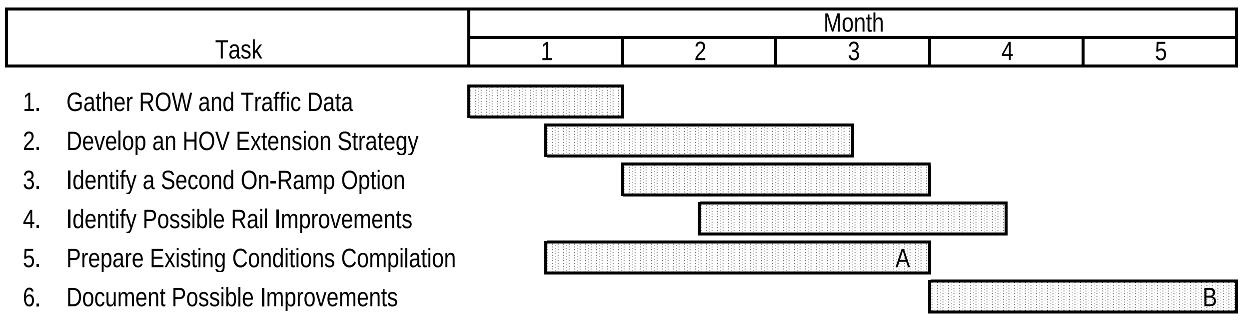
The total cost of this project is estimated to be $79,957. This includes the cost of 29.5 person-weeks of staff time, overhead at the rate of 88.99 percent, and travel. A detailed breakdown of estimated costs is presented in Exhibit 2.

AJS/WSK/wsk

Exhibit 1

ESTIMATED SCHEDULE

HOV Lane and I-93 Access Improvements in the South Bay/Savin Hill Area



Products/Milestones

A: Existing conditions compilation

B: Memorandum describing possible improvements

Exhibit 2
ESTIMATED COST
HOV Lane and I-93 Access Improvements in the South Bay/Savin Hill Area

Direct Salary and Overhead	$79,157

Task	Person-Weeks							Direct	Overhead	Total
	M-1	P-5	P-4	P-2	P-1	Temp	Total	Salary	(@ 88.99%)	Cost
1. Gather ROW and Traffic Data	0.0	3.0	0.0	0.0	0.0	3.0	6.0	$6,313	$5,618	$11,931
2. Develop an HOV Extension Strategy	0.5	1.0	0.0	0.0	0.0	0.0	1.5	$2,414	$2,148	$4,562
3. Identify a Second On-Ramp Option	0.5	1.0	0.0	0.0	0.0	0.0	1.5	$2,414	$2,148	$4,562
4. Identify Possible Rail Improvements	0.0	1.0	0.0	0.0	0.0	0.0	1.0	$1,595	$1,420	$3,015
5. Prepare Existing Conditions Compilation	0.0	4.0	1.0	0.0	0.0	0.0	5.0	$7,601	$6,764	$14,365
6. Document Possible Improvements	2.0	10.0	1.0	0.5	1.0	0.0	14.5	$21,547	$19,175	$40,722
Total	3.0	20.0	2.0	0.5	1.0	3.0	29.5	$41,884	$37,273	$79,157

Other Direct Costs	$800
Travel	$800

TOTAL COST	$79,957

Funding
MassDOT FTA §5303 Transit Planning Contract #80-0004; MassDOT 3C PL Highway Planning Contract #59796

MEMORANDUM

To: **Transportation Planning and Programming Committee** **April 22, 2010**

From: Seth Asante and Efi Pagitsas

Re: **Safety Evaluation of Transportation Improvement Program Projects**

BACKGROUND

In the recent past, the issue of safety, as it relates to the process of project selection in the Transportation Improvement Program (TIP) of the Boston Region Metropolitan Planning Organization (MPO), has been discussed at meetings of the Transportation Planning and Programming Committee (TPPC) and its subcommittees. TPPC members expressed interest in the feasibility of predicting how well a given project selected for funding in the TIP would address safety concerns at that location.

Currently, project proponents are asked to discuss the safety issues associated with a project area, and the way in which the proposed project would address those issues. This tends to elicit fairly qualitative information from proponents. MPO staff then provide information necessary for rating projects on the basis of the project's:

- Rank: Is it on the list of the top 200 crash locations?
- Three-year crash total
- Fatal crashes
- Bicycle- and pedestrian-involved crashes
- Crash rates

All of this information, qualitative and quantitative, helps to illuminate safety-related need for a particular project. None of this, however, provides the Boston Region MPO with any rigorous assessment of whether the design of a project, as proposed, would definitely reduce crashes at the project location.

To address the TPPC's interest in a detailed safety analysis that would assess the safety potential of a TIP project, staff proposed an approach [1] As a result, the Boston Region MPO approved in their FFY 2009 UPWP the funding of this pilot study to explore the merits of such an approach. This study analyzed the proposed two-step process: the first step would entail a more thorough

[1] Karl H. Quackenbush and Efi Pagitsas, "Proposed Approach for Evaluating the Safety Implications of Projects Proposed for the TIP," memorandum, April 2008.

evaluation of current crashes at a project location than is generally done in the current process, while the second would involve predicting the crash reduction potential of a proposed project.

OBJECTIVE

The purpose of this study was to select several TIP projects in order to evaluate the potential of the proposed improvements to reduce crashes for each project. To this end, the staff pursued the following objectives:

- Identified TIP projects to analyze for safety
- Evaluated each project's recent crash experience
- Evaluated each project's crash reduction potential
- Documented and presented the findings

IDENTIFY WHICH TIP PROJECTS TO ANALYZE FOR SAFETY

Review of TIP Projects

TIP projects with 25 percent or 75 percent design status and an available functional design report (FDR) would qualify for analysis. The reason for choosing 25 percent or 75 percent design was that project plans at these stages are better defined and therefore ready for the MPO comments on the appropriateness of the safety improvements that are included in the plans related to the identified safety needs.

MPO staff obtained a list of the TIP universe of projects in late November 2008. From this list, they selected all those projects at 25 percent or 75 percent design status for further evaluation. There were 50 projects in this category. Staff then used the MassHighway Project Information database to verify the current status of each project. Staff also called and visited MassDOT Highway Division (then MassHighway) project managers to discuss the status of each project and to obtain additional information on current plans and design reports. This task began in early December and lasted for about three weeks. The results of the evaluations, which are illustrated in a flow diagram (in Figure 1):

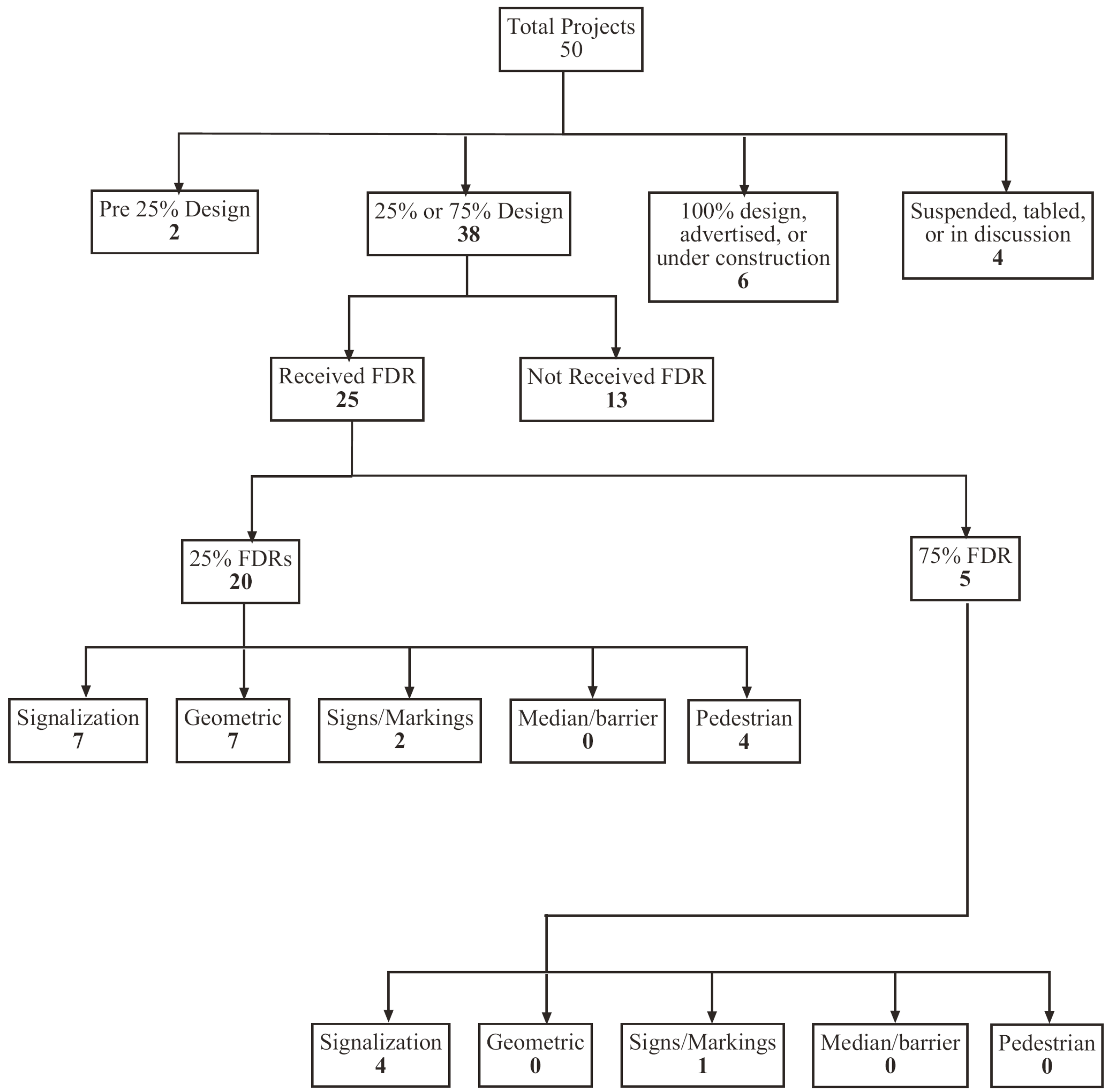
- Six TIP projects at 75 percent design status had already advanced to 100 percent design, and had been submitted and approved, advertised, or under construction. These projects were excluded from further evaluation.

- Four TIP projects had been suspended, tabled, or in were discussion. These projects were excluded from further evaluation.

- Two TIP projects were identified to be at pre-25-percent-design status. These projects were excluded from further evaluation.

- Thirty-eight projects, on the list were identified to meet the 25 percent or 75 percent design status for further evaluation.

FIGURE 1
Safety Evaluation in the Selection of Transportation Improvement Projects



Request for Functional-Design Reports

After reviewing the TIP projects, staff requested FDRs from MassDOT's Highway Division for the 38 TIP projects that were at 25 percent or 75 percent design status. The purpose of the request was to obtain information on the following:

- The need for the project
- The crash data and information on safety
- The types of improvements proposed in the project

Staff received FDRs for 25 of the 38 TIP projects. Staff did not receive FDRs for the other 13 projects because those reports were not readily available; the project managers would have had to request them from a consultant or a municipality. Overall, it took about two weeks to receive the 25 reports. Table A-1 (Appendix A) shows the projects for which we obtained an FDR—they are indicated by a blue background. TIP projects for which we were unable to obtain an FDR reports are indicated by a white background. TIP projects that are pre-25 percent or post-75 percent design, suspended, tabled, or in discussion are indicated by a yellow background. After receiving the FDRs, staff reviewed them.

Review of Project Safety Needs

Table A-1 (Appendix A) provides, for each project, a description the project's safety needs, safety information, and recommended improvements. Staff used the MassDOT Highway Division's 2004–2006 crash data and intersection crash-cluster information to determine the current Equivalent Property Damage Only (EPDO) for each project, which is presented in Table A-1. The EPDO method takes into account the total number of crashes at a location and the severity of each crash. The MassDOT Highway Division currently uses this system in its development of the list of the top 1,000 high-crash locations in Massachusetts. The EPDO method is a system of ranking intersections in terms of safety. The system is point based (weighted), with different types of crashes receiving different weights: 1 point for a property-damage-only crash or not reported/unknown severity crash, 5 points for an injury crash, 10 points for a fatal crash. The formula for determining the EPDO is as follows:

EPDO = (1 x number of property-damage-only crashes) + (5 x number of injury crashes) + (10 x number of fatal crashes)

In addition, staff determined whether or not a project is included in the list of the top 200 intersection crash clusters for Massachusetts or in the top 5 percent of intersection clusters for the Boston Region MPO area. These thresholds are project selection criteria for the Highway Safety Improvement Program (HSIP) to reduce the number of fatal and injury crashes by targeting high crash location.

As part of the review, staff determined whether the project safety recommendations were based on simple crash totals and frequencies, calculations of crash rates, or detailed collision diagrams. The majority of the safety analyses in the FDRs were based on crash totals and frequencies and calculations of the crash rates, which were then compared to MassDOT Highway Division district averages (see Table A-1). Very few FDRs contained detailed collision diagrams, which show the specific locations and movements of vehicles involved in crashes. Collision diagrams help to display and identify similar crash patterns, and they are used to evaluate specific sites for possible causes of crashes.

Furthermore, many of the projects serve a dual purpose—to address both safety and traffic operations problems—because high-crash locations are usually locations with high-volume traffic operations. There were few projects that addressed a single intersection; the majority of the projects covered sections of roadways that have more than one intersection.

Selection of Projects for Evaluation

After reviewing the 25 TIP projects, MPO staff selected seven projects for evaluation. The focus was to select a variety of projects with the following types of improvements: signalization, geometric improvements, signs and markings, pedestrian/bicycle improvements, and roadway segment improvements. Other selection criteria included geographic location, a combination of improvements, and whether or not adequate crash data were available for use in proposing the improvements. While crash totals and frequencies and rates indicate the need for safety improvements, they do not in themselves provide any information on the effectiveness of proposed improvements. Examination of the collision diagrams of crashes, which show vehicle maneuvers, the location of the crashes, and crash patterns, is needed to determine the possible causes of the crashes and evaluate the effectiveness of the proposed safety improvements.

Of the 25 TIP projects, only five had collision diagrams. Those five projects were selected for further evaluation. In addition, two other projects without collision diagrams were selected for evaluation. The reasons for selecting these two projects were that the FDRs explicitly identified the crash patterns and the primary movements involved in the crashes and gave the primary cause of the crashes. The seven projects are presented in Table 1.

TABLE 1
Projects Selected for Evaluation

Project	Location	Collision Diagram
Trapelo Road and Belmont Street Corridor Improvements	Belmont	Yes
Route 16 Traffic Signal Improvements	Milford	Yes
Route 53 (Washington Street)/Middle Street	Weymouth	Yes
Reconstruction of Temple Street	Somerville	Yes
Central Avenue Rehabilitation Project	Milton	Yes
Highland Avenue Corridor Improvements	Needham	No
Route 139 (Plain Street) Corridor Improvement Study	Marshfield	No

CRASH REDUCTION FACTORS

Crash Reduction Factors (CRFs) are defined as "mathematical and statistical tools used to estimate the effects on safety of planned improvements to streets and highways."[2] CRFs are developed using data on vehicle crashes, roadway geometric data, traffic volume data, and other types of roadway and traffic data. CRF values are typically obtained from before-and-after studies on selected sites for which safety improvements are done. In some cases, they are obtained from statistical methods such as regression analysis, cross-sectional studies, controlled experiments, and empirical Bayes methods.

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[2] U.S. Department of Transportation, Federal Highway Administration, *Desktop Reference for Crash Reduction Factors*, Publication No. FHWA-SA-07-015, September 2007.

CRFs provide a quick way of estimating crash reductions associated with highway safety improvements in order to measure the effectiveness of safety improvements. CRFs are used by many states and local jurisdictions in program planning to decide whether to implement a specific treatment and/or to quickly determine the costs and benefits of selected alternatives.

The next section describes impediments in the use of CRFs in safety evaluations.

CONSIDERATIONS FOR USING CRFs

Accurate CRFs are required in order to achieve the greatest return on investment when choosing among alternative treatments. Reliable CRFs may also be used in the development of broad-based policy decisions related to project planning and design. Given the importance of CRFs in decision-making processes, it is critical to address the impediments that prevent more extensive use of CRFs. These impediments include the following.[3]

Origins and Transferability

The origins of CRFs are not always clear to the end user. Some states have developed CRFs using their own crash data. Other states have simply adopted CRFs that were developed in other states. The extent to which CRFs are valid when transferred to places beyond the development domain (for example, from one state to another), where roadway, traffic, weather, driver characteristics, crash investigation practices, and other relevant characteristics are different, is unknown.

Methodological Issues

Many existing CRFs are derived from before-and-after analysis of actual improvement implementation. Indeed, such before-and-after studies, as opposed to cross-sectional regression analysis, produce the best CRF estimates, but only if conducted properly. Unfortunately, many current studies reflect changes in crash characteristics resulting from improvements at sites that had experienced unusually high crash rates in the before-treatment period. The selection bias inherent in this approach often results in significantly exaggerated CRF estimates due to the phenomenon of regression to the mean.

Crash Migration and Spillover Effects

After improvements have been implemented at a particular location, crashes may migrate to adjacent locations. For example, the prohibition of left turns at an intersection may lead to an increase in left-turn crashes at upstream and downstream intersections. Existing CRFs rarely account for this phenomenon. For CRFs to be useful, they have to account for these effects, or at least recognize their existence.

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[3] Transportation Research Board of the National Academies, *Research Results Digest 299,* National Cooperation Highway Research Project, Washington, DC, November 2005.

Lack of Information on Effectiveness

CRFs have not been developed for many intelligent transportation systems (ITS) treatments or other operational strategies. For example, on many freeways, safety service patrols have become more common as a way of reducing the impact of incidents and reducing secondary crashes. However, no CRFs exist for this improvement. Other ITS treatments of interest for which no reliable CRFs exist include pedestrian safety treatments, such as in-pavement lighting and dynamic or changeable message signs, including those related to variable speed limits.

Combinations of Treatments

Most CRFs are designed for individual treatments. However, when a facility is being rebuilt, there are usually multiple treatments and states use different formulas for combining individual CRFs when considering multiple treatments. Since there is very little sound research on the multitude of actual combinations of treatments currently in use, it is unknown whether current predictions based on combining individual CRFs accurately capture the combined effect of multiple treatments.

Publication and Citation Issues

Another issue of concern that is prevalent in much of the research is the quality of the material that is available and often used in the development of CRFs. Specific problems include:

- Publication bias (the tendency to only publish studies that produced favorable results for the treatment being evaluated).

- Selective citing of results (for example, the tendency to ignore negative aspects of results, such as declining effects over time or unintended consequences that would lead to increases in some types of crashes). In some cases, a sponsoring organization may not want negative results published if they invested significant funds in an improvement program.

THE EFFECTS OF USING MULTIPLE IMPROVEMENTS

As identified above, it is typically the case that more than one treatment is used at the same location (an intersection or roadway segment). For example, for a section of two-lane roadway where there are safety problems due to a bottleneck and high volumes of turning traffic, an attempt may be made to expand the roadway section to four lanes, install left-turn bays, and make improvements in traffic signal phasing. Although in some cases there is clearly a primary treatment (one treatment that will provide the main crash reduction benefit), in other cases several treatments may act together to improve safety, as in the example below.

One example is a hypothetical case where, when three treatments are being considered in one location, with respective CRFs of 40 percent, 25 percent, and 45 percent, simply adding them would result in a 110 percent reduction. This implies that the treatments will not only prevent future crashes altogether but also prevent crashes that have already occurred. Thus, the example shows the importance of applying a reasonable methodology when calculating the combined effects of multiple treatments to account for the diminishing benefit from using multiple treatments due to interactions among the treatments.

Combining Crash Reduction Factors for a Single Location

For a project location such as an intersection or roadway segment, a review of the literature revealed that the commonly used equation that creates a single crash reduction factor for multiple treatments applied at the location is described below (Equation 1).[4]

(Equation 1)

$$CRF_t = 1 - (1 - CRF_1)(1 - CRF_2)(1 - CRF_3) + \ldots + (1 - CRF_i)$$

where CRF_t = total crash reduction, and
CRF_i = individual crash reduction factors for a given treatment and crash type.

Using the example above, the total or combined crash reduction factor was calculated as:

$$\begin{aligned} CRF_t &= 1 - (1 - 0.4)(1 - 0.25)(1 - 0.45) \\ &= 1 - (0.6 \text{ x } 0.75 \text{ x } 0.55) \\ &= 0.75\text{, or a 75\% reduction in crashes} \end{aligned}$$

A 75 percent reduction in crashes is obviously less than the 110 percent reduction that would be calculated if the reductions were just added together.

Expected Crash Reduction

The expected number, by crash type, of crashes reduced is determined by multiplying the number of crashes before treatment by the crash reduction factor. The number of crashes reduced needs to be corrected by the projected growth in traffic after treatment. The following equation calculates the expected number of crashes reduced by treatments at a given location.

(Equation 2)

$$N_r = \sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i$$

Where
N_r = total number of crashes reduced
ADT_a = projected ADT (average daily traffic) at location after treatment
ADT_b = ADT for the analysis period (before)
N_b = number of crashes in crash type i during analysis period

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4 J. Kevin Lacy, Recommended Procedure for Combining Crash Reduction Factors, Highway Safety Research Center, North Carolina Department of Transportation, Raleigh, North Carolina, May 2001; and D. W. Harwood, F. M. Council, E. Hauer, W. E. Hughes, and A. Vogt, *Prediction of The Expected Safety Performance of Rural Two-Lane Highways*, Federal Highway Administration, Washington, DC, December 2000.

CRF_i = crash reduction factor for crash type *i* due to treatment (may be combined crash types, e.g., all crash types, left-turn, and pedestrian)
i = different crash types that treatments affect at the treated location

Combining Crash Reduction Factors for More than One Location

Many projects encompass a long stretch of roadway and have more than one treatment location where one type of treatment may be applied, such as adding left-turn lanes at several different intersections along a corridor and widening the paved shoulder along the entire project limits. Determining the number of crashes reduced in these cases is very similar to the method used in the previous section (Equation 2, on page 8). However, one will need to complete the analyses for each location and treatment. The total number of crashes reduced on a project is the sum of the crashes reduced for each location, based upon all the treatments applied in the project. For combining crash reduction factors affecting more than one location, such as a roadway segment (multiple locations), Equation 3 is used to calculate the total number of crashes reduced, where *i* and *j* indicate the different crash types and different entities, respectively.

(Equation 3)

$$N_r = \sum_j \left[\sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i \right]$$

Where

N_r = total number of crashes reduced
ADT_a = projected ADT at location after treatment
ADT_b = ADT for the analysis period (before treatment)
N_b = number of crashes in crash type *i* during analysis period
CRF_i = crash reduction factor for crash type *i*
i = different crash types that treatments affect at the treated location
j = different entities within the treatments area

Validation of Equations

None of three equations above appears to have been validated with empirical data. An attempt at validation was made based on New Zealand crash-monitoring data.[5] The analysis was undertaken on the crash reduction effectiveness of several single treatments, and this information was compared with the effect of using these same treatments in combination. The results showed that the equations overestimate the benefits of combined treatments. Based on the results of that analysis, the authors recommended that in order to provide a more accurate estimate of crash reduction, the combined crash reduction estimates derived using these equations should be multiplied by 0.66. Thus, in the example above, instead of a 75 percent reduction, the treatments would result in a 50 percent reduction. Of course, more empirical data are needed to validate these

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[5] Blair Turner, Senior Research Scientist of ARRB Group. Abstract of his presentation at the Australasian Road Safety Research Policing and Education Conference, “Research to Improve the Accuracy of Economic Evaluations in Road Safety,” October 17–19, Melbourne, Australia. [To read the abstract, use a search engine; search on author's name and title of abstract. Select the correct link to directly download the abstract (there is no URL that will link to the abstract.)]

formulas for conditions in the U.S., and the Boston Region MPO could choose not to apply this factor in their evaluations. Since the literature suggests that CRFs are optimistic and overestimate benefits of improvements, the 0.66 factor was applied in this pilot study.

SAFETY EVALUATIONS

To properly evaluate safety for the selected projects, staff first looked at the crash information provided in the functional design reports (FDRs). Staff inspected the crash totals, frequencies, and characteristics for each project, and then looked at the crash rates and determined whether they exceeded MassDOT Highway Division district averages. Staff then reviewed the project's crash patterns by inspecting the crash diagrams to identify similar crash patterns and possible causes of crashes. Two of the selected projects did not have crash diagrams, as discussed above, but contained explicit descriptions of the locations and causes of the crashes.

After reviewing the crash information, staff assessed the improvements included in the projects to ascertain if they addressed the safety needs identified for the projects. They then looked up the CRFs for each of the proposed improvements. (CRFs are used to evaluate the effectiveness of a treatment in reducing certain types of crashes.) The CRFs for the proposed improvements were obtained from the Federal Highway Administration's Desktop Reference for Crash Reduction Factors.[6] After obtaining the CRFs, staff used the equations described above (on pages 7 and 8) to calculate the reductions in crashes for each of the projects. The reductions were based of the 2004–2006 crash database to provide a baseline for comparison (note that the FDRs were prepared in different years and use different databases). Figure 2, below, is a flow chart showing the safety evaluation process. The following sections describe the safety evaluations of the selected projects.

TRAPELO ROAD AND WALTHAM STREET[7]

Project Need

According to the FDR, this project is located in Belmont and would reconstruct Trapelo Road and Belmont Street from the Cambridge city line to the Waltham city line. The report indicates that the project corridor experiences excessive traffic delays at certain intersections, and the closely spaced signalized intersections are not interconnected or coordinated for efficient traffic operations. In addition, safety is an issue in the corridor for pedestrians, bicyclists, and motorists.

The project would update signals and timing and improve roadway conditions to accommodate increased traffic volumes; specific improvements proposed in the corridor include widening to two travel lanes in each direction at some segments of the corridor, install interconnected, coordinated traffic control, and provide exclusive left-turn lanes and phases in the project area. Improved

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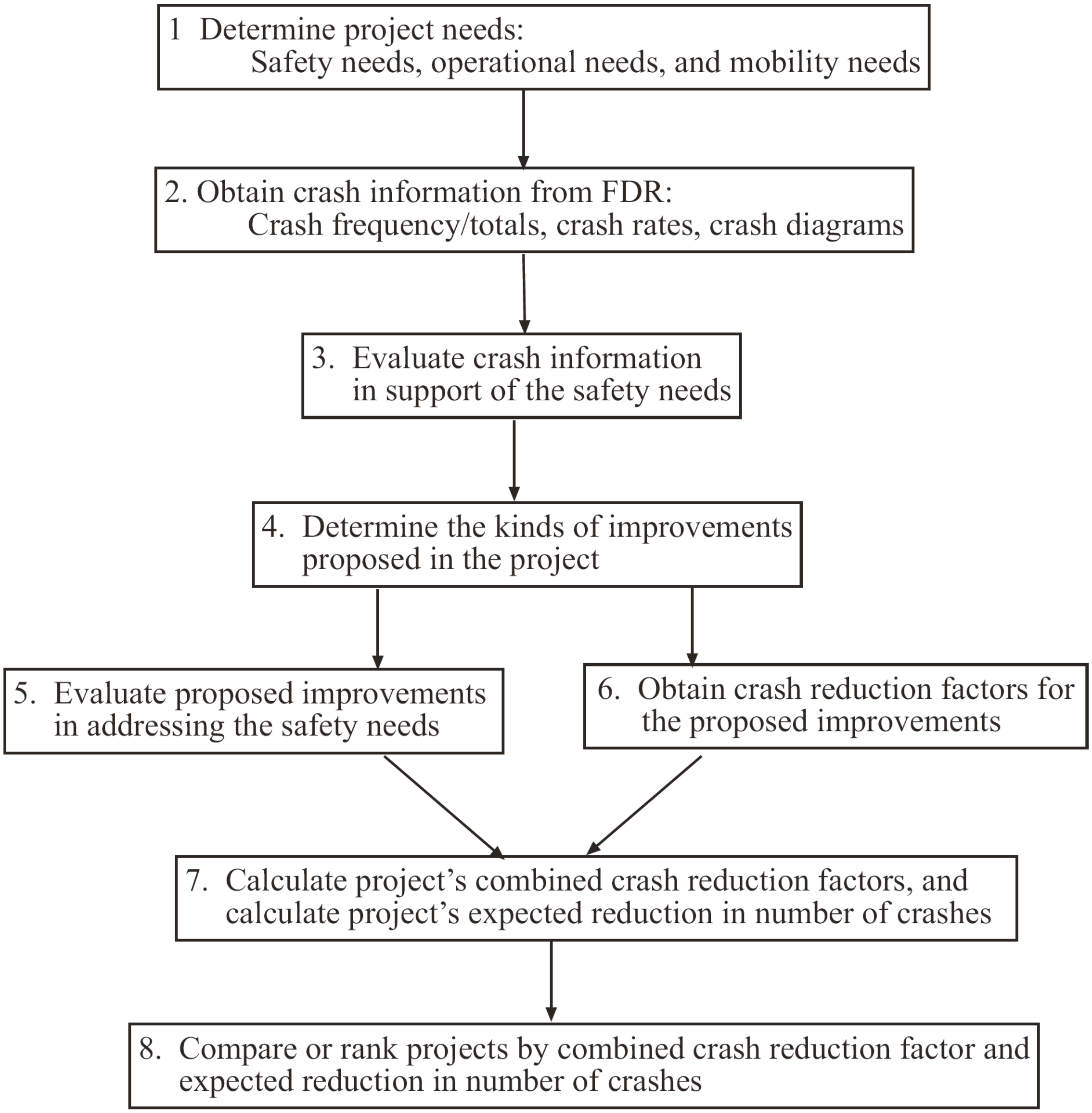
6 U.S. Department of Transportation, Federal Highway Administration, *Desktop Reference for Crash Reduction Factors*, Publication No. FHWA-SA-07-015, September 2007.

7 BSC Group, *Functional Design Report, Trapelo Road/Belmont Street Corridor Improvements*, prepared for the Town of Belmont, Boston, MA, August 2007.

FIGURE 2
Safety Evaluation Process



pedestrian access, shortened crosswalks, and bicycle accommodation would also address pedestrian and bicycle needs in the project area.

Safety Assessment

Table B-1, in Appendix B, shows the crash frequencies and rates for the Trapelo Road and Waltham Street project. Only one intersection exceeded the MassDOT Highway Division average. In the corridor, there were 180 crashes between 2003 and 2005 at the intersections, according to the FDR. The 2004–2006 crash database indicates that there were 317 crashes in the intersection clusters for this project corridor. For consistency, the 2004–2006 crash database was used in the analysis to provide a consistent baseline for all the projects in this study. Collision diagrams had been prepared for only five intersections; they are in Appendix C. The collision diagrams show that rear-end and angle collisions constituted the majority of the crashes in the corridor. The angle collisions involved left turns at signalized and unsignalized intersections that lacked turn bays. They also involved cross movements at four-legged intersections, where drivers run red lights or enter the intersection with an insufficient gap for safely crossing the intersection. Rear-end collisions were also common at intersections throughout the corridor. There were two pedestrian crashes were at Trapelo Road and Belmont Street.

Crash Reduction

Table 2 shows the major improvements proposed in the project and their effectiveness in reducing crashes. All of the proposed improvements addressed safety needs in the corridor for pedestrians, bicyclists, and vehicular traffic. The individual improvements have positive CRFs ranging between 15 percent and 58 percent. The entire 2.6-mile project corridor, with more than 50 intersections, was divided into three uniform sections based on the type of treatment. The lengths of Sections 1, 2, and 3 are 0.9 miles, 1.2 miles, and 0.5 miles, respectively, and each of the three sections has uniform treatments throughout. It would require tremendous work and time to analyze each intersection and roadway segment in between them as separate locations, and it would provide little benefit.

One can clearly see, from looking at the improvements in Table 2, the effects of multiple treatments. The interconnection and coordination of traffic control, exclusive left-turn lanes and signal phases, and widened of the roadways to two traffic lanes in each direction have common effects on certain crash types. For example, widening Trapelo Road to two travel lanes in each direction would not only make it easier to coordinate traffic control throughout the corridor, but the provision of exclusive left-turn lanes and phases would also facilitate traffic control coordination. Thus, in this project, some of the treatments may act together to improve safety. Using the formula for multiple treatments, the expected combined CRF for each section was calculated using Equation 1 (on page 8):

Section 1: CRF_{t1} = 1 - (1 - 0.15)(1 - 0.58)(1 - 0.50)
= 1 - (0.85 x 0.42 x 0.50)
= 1 - 0.18
= 0.82, or an 82% reduction in crashes

Section 2: CRF_{t2} = 1 - (1 - 0.58)(1 - 0.15)(1 - 0.25)(1 - 0.50)
= 1 - (0.42 x 0.85 x 0.75 x 0.50)
= 1 - 0.13
= 0.87, or an 87% reduction in crashes

Section 3: CRF_{t3} = 1 - (1 - 0.20)(1 - 0.50)
= 1 - (0.80 x 0.50)
= 1 - 0.40
= 0.60, or a 60% reduction in crashes

TABLE 2
Trapelo Road and Waltham Street:
Effectiveness of the Proposed Improvements

Improvement	Safety Need Addressed	Crash Type	Crash Severity	Crash Reduction Factor
Section 1: Waverly Oaks Road to Hull Street (0.9 miles)				
Install interconnected, coordinated traffic control throughout the corridor	Reduce stops and hence rear-end crashes	All	All	15
Provide exclusive left-turn lane and add left-turn phase (several locations)	Reduce left-turn-related crashes	All	All	58
Provide bicycle accommodation by widening lanes	Reduce bicycle-related crashes	All	All	50
Section 2: Hull Street to School Street (1.2 miles)				
Provide exclusive left-turn lane and add left-turn phase (several locations)	Reduce left-turn-related crashes	All	All	58
Interconnected, coordinated traffic control throughout the corridor	Reduce stops and hence rear-end crashes	All	All	15
Install raised median	Reduce crashes	All	All	25
Provide bicycle accommodation by widening lanes	Reduce bicycle-related crashes	All	All	50
Section 3: School Street to Brimmer Street (0.5 miles)				
Widen Trapelo Road to two lanes throughout the corridor	Reduce rear-end crashes	All	All	20
Provide bicycle accommodation by widening lanes	Reduce bicycle-related crashes	All	All	50

The combined CRF estimate for each section was multiplied by 0.66; this would result in a 54 percent, 57 percent, and 40 percent reduction in crashes for Sections 1, 2, and 3, respectively. According to the 2004–2006 crash database, there were 161 crashes in Section 1, 95 crashes in Section 2, and 61 crashes in Section 3. Assuming that average daily traffic (ADT) will remain the same after treatment, the expected reduction in the number of crashes, based on the 2004–2006 crash database, was calculated using Equation 2 (on page 8) for each of the three roadway sections.

$$\text{Expected reduction in number of crashes} = \sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i$$

$$\text{Expected reduction in number of crashes in Segment 1} = 1 * \frac{161}{3} * 0.54 = 29 \text{ crashes per year}$$

$$\text{Expected reduction in number of crashes in Segment 2} = 1 * \frac{95}{3} * 0.57 = 18 \text{ crashes per year}$$

$$\text{Expected reduction in number of crashes in Segment 3} = 1 * \frac{61}{3} * 0.40 = 8 \text{ crashes per year}$$

Finally, the expected reduction in number of crashes per years for all of the sections combined was calculated using Equation 3 (on page 9).

Expected reduction in number of crashes = 29 + 18 + 8 = 55 crashes per year

ROUTE 16 TRAFFIC SIGNAL IMPROVEMENT PROJECT[8]

Project Need

According to the FDR, this project, located in the downtown area of Milford, begins at the intersection of Route 16 and Route 109, and continues southward along Route 16 approximately 1.5 miles to the intersection of Route 16, South Main Street/Congress Street, and Water Street. The report indicates that seven traffic signals in the project area would be retimed, interconnected, and coordinated as they are currently not operating efficiently, and are experiencing excessive traffic delay, a higher-than-expected number of crashes, and pedestrian mobility problems. All of the seven traffic signal controls are missing essential signal equipment or are currently using outdated signal equipment, resulting in less-than-optimal operational conditions. The proposed improvements would establish fully optimized signal operations and improve safety along the corridor to allow safe and efficient traffic flow while addressing pedestrian needs.

Safety Assessment

Table B-2, in Appendix B, shows the crash frequencies and rates for the project intersections. The crash rates of three intersections exceeded the MassDOT Highway Division district average; these were the intersections for which collision diagrams collision diagrams had been prepared (see Appendix C). According to the FDR, there were 170 crashes between 2001 and 2003 at the study intersections in the corridor. The 2004–2006 crash database indicates that there were 142 crashes in the corridor. For consistency, the 2004–2006 crash database was used in the analysis to provide a consistent baseline for all the projects in this study.

According to the 2001–2003 collision diagrams prepared for the FDR and the 1997–1999 collision diagrams prepared by CTPS for the project area and documented in the report *Traffic Congestion in the SouthWest Advisory Planning Subregion,* rear-end and angle collisions constituted the majority of the crashes in the corridor.[9] The angle collisions involved left turns and cross movements at intersections, where drivers turn through insufficient gaps, run red lights, or enter the intersection with insufficient time to safely cross the intersection. The rear-end collisions were also common at intersections throughout the corridor, due to peak-hour traffic

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[8] MS Transportation Systems Inc., *Traffic Analysis/Functional Design Report, Route 16 Traffic Signal Improvements*, prepared for the Town of Milford and Massachusetts Highway Department, Framingham, MA, March 2006.

[9] Seth Asante, *Traffic Congestion in the SouthWest Advisory Planning Subregion*, October 2002.

congestion. The reports cited pedestrian crashes at three intersections along Route 16: Route 109, Route 85, and South Main Street/Congress Street.

Crash Reduction

Table 3 shows the major improvements proposed in the project and their effectiveness in reducing crashes. All of the improvements have positive CRFs, ranging from 8 percent to 70 percent. The multiple treatments suggested for the corridor implies some treatments may have common effects. The traffic control interconnection and fully actuated controller make it easier to implement optimized signal timing and emergency preemption. Pedestrian phases with push buttons and pedestrian countdown signals all help to reduce pedestrian crashes and therefore may complement each other.

The CRF resulting from the provision of emergency preemption affects only collisions involving emergency vehicles. No emergency-vehicle-related crashes were reported for the corridor during the 2004–2006 period. Similarly, the CRF for pedestrian countdown signals affects only crashes involving pedestrians. There were six pedestrian crashes during the 2004–2006 period. The entire 1.6-mile project corridor is considered a single roadway segment, as the types of improvements at each of the closely spaced signalized intersections are the same throughout the corridor. The suggested improvements would even impact some of the minor unsignalized intersections, which are not included in the optimization and coordination of traffic signal controls. The improvements that affect specific crash types, such as emergency-vehicle and pedestrian crashes, were treated separately.

TABLE 3
Route 16 Traffic Signal Improvement Project:
Effectiveness of the Proposed Improvements

Improvement	Safety Need Addressed	Crash Type	Crash Severity	Crash Reduction Factor
Install fully actuated traffic signal controller	Reduce left- and right-turn related crashes	All	All	40
Optimize traffic signal timing	Reduce rear-end crashes	All	All	8
Replace signal lenses with 12” LED type	Reduce crashes involving running red lights	All	All	10
Provide pedestrian phase with push buttons	Reduce pedestrian-related crashes	All	All	20
Provide emergency pre-emption for all approaches	Reduce crashes involving emergency vehicles	Emergency vehicle	All	70
Provide countdown pedestrian signals	Reduce pedestrian-related crashes	Pedestrian	Injury/fatal	34

The expected combined CRF for the treatments, with the exception of the emergency preemption and countdown pedestrian signal, was calculated using Equation 1 (on page 8):

$$\begin{aligned} CRF_t &= 1 - (1 - 0.4)(1 - 0.08)(1 - 0.10)(1 - 0.2) \\ &= 1 - (0.60 \times 0.92 \times 0.90 \times 0.8) \\ &= 1 - 0.40 \\ &= 0.60\text{, or a 60\% reduction in crashes} \end{aligned}$$

The combined CRF estimate of 60 percent is multiplied by 0.66; this would result in a 40 percent reduction in crashes for the project area. Assuming that ADT (average daily traffic) would remain the same after treatment, the expected reduction in the number of crashes, based on the 2004–2006 crash database, was calculated using Equation 2 (page 8):

$$\text{Expected reduction in number of crashes} = \sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i$$

$$\text{Expected reduction in number of crashes} = 1 * \frac{142}{3} * 0.40 = 19 \text{ crashes per year}$$

The expected combined CRF for emergency preemption and countdown pedestrian treatments, using Equation 1:

$$\begin{aligned} CRF_t &= 1 - (1 - 0.7)(1 - 0.34) \\ &= 1 - (0.30 \times 0.64) \\ &= 1 - 0.19 \\ &= 0.81\text{, or an 81\% reduction in crashes} \end{aligned}$$

The combined CRF estimate of 81 percent is multiplied by 0.66; this would result in a 53 percent reduction in crashes for the project area. There were six pedestrian and no emergency vehicle related crashes during the 2004–2006 period. Assuming that the ADT would remain the same after treatment, the expected reduction in the number of pedestrian and emergency crashes would be (0.53x 6) = 3 or 1.5 per year.

The overall expected reduction in the number of crashes = 19 + 2 = 21 crashes per year.

ROUTE 53 (WASHINGTON STREET) AND MIDDLE STREET, WEYMOUTH[10]

Project Need

According to the FDR, the intersections of Washington Street and Middle Street and Middle Street and Winter Street in Weymouth are not only operating with excessive delays but also have

[10] VHB/Vanasse Hangen Brustlin Inc., *Functional Design Report, Middle Street – Two Locations*, prepared for Massachusetts Highway Department, Watertown, MA, June 1997; and John W. Diaz and Joseph P. Johnson, Greenman Pedersen Inc., "Route 53 at Middle Street and Winter Street at Middle Street," technical memorandum to Thomas Currier, Massachusetts Highway Department, January 2009.

safety deficiencies. The report indicates that the existing traffic control system is old and outdated, and the need therefore exists to upgrade the traffic control signal system and implement geometric improvements to address pedestrian and traffic safety problems at the intersection. The project would widen the roadway, make geometric improvements, and install new sidewalks, signs, and pavement markings to address safety and operations needs.

Safety Assessment

This project comprises two signalized intersections, very close to each other, both of which have high crash rates that exceeded the MassDOT Highway Division district average. The Washington Street and Middle Street intersection is in the 2004–2006 statewide list of the top 200 high-crash intersection locations and also in the top 5 percent of high-crash locations in the Boston Region MPO area. There were 57 crashes from 1990 to 1993 at the Washington Street and Middle Street intersection, with a crash rate of 3.57 million entering vehicles (MEV), which exceeds the MassDOT Highway Division average for a signalized intersection. The 2004–2006 crash database shows that there were 77 crashes at the Washington Street and Middle Street intersection, a 35 percent increase over 1990–1993. In addition to the 77 crashes, there were 16 other crashes close to this intersection.

The collision diagrams for the 1990–1993 crashes used to prepare the FDR are included in Appendix C. The collision diagrams show that angle/sideswipes collisions constitute the majority of the crashes at this intersection (64 percent). These collisions involve drivers making left turns through insufficient gaps to safely cross the intersection.

At the Middle Street and Winter Street intersection, no crash data were provided in the FDR for the period 1990–1993. However, the 2004–2006 crash database indicated that there were 33 crashes at this intersection. No collision diagrams were provided for the intersection Middle Street and Winter Street.

Crash Reduction

Table 4 shows the improvements proposed in the project and their effectiveness in reducing crashes. All of the major improvements have positive CRFs ranging between 8 and 80 percent. The crash reduction factor of 80 percent for installing a fully actuated traffic signal is only for left-turn-related crashes. The multiple treatments have common effects at both intersections.

The entire project is considered as a single roadway segment because the two intersections are close to each other and are therefore each is affected by improvements at the other. Given the closely spaced intersections and the treatments’ common effects, the expected combined CRF for all the treatments in this project was calculated using Equation 1 (on page 8):

$$
\begin{aligned}
CRF_t &= 1 - (1 - 0.58)(1 - 0.80 \times 0.64)(1 - 0.10)(1 - 0.15)(1 - 0.25)(1 - 0.18)(1 - 0.09) \\
&= 1 - (0.42 \times 0.49 \times 0.90 \times 0.85 \times 0.75 \times 0.82 \times 0.91) \\
&= 1 - 0.09 \\
&= 0.91\text{, or a 91\% reduction in crashes}
\end{aligned}
$$

TABLE 4
Route 53 (Washington Street) and Middle Street, Weymouth:
Effectiveness of the Proposed Improvements

Improvement	Safety Need Addressed	Crash Type	Crash Severity	Crash Reduction Factor
Install left-turn lanes and phases at both intersections	Reduce left-turn-related crashes	All	All	58
Install fully actuated traffic signal controller	Reduce left- and right-turn related crashes	Left-turn	All	80
Upgrade signal heads to 12" LED	Reduce crashes involving running red lights	All	All	10
Provide signal coordination	Reduce rear-end crashes	All	All	15
Provide split phases for Middle Street approaches	Reduce left-turn-related crashes	All	All	25
Provide pavement markings	Reduce all types of crashes	All	All	18
Implement signs to MUTCD standards	Reduce all types of crashes	All	All	9

The combined CRF estimate of 91 percent is multiplied by 0.66; this would result in a 60 percent reduction in crashes for the project area. Assuming that the ADT would remain the same after treatment, the expected reduction in the number of crashes, based on the 2004–2006 crash database, was calculated using Equation 2 (on page 8):

$$\text{Expected reduction in number of crashes} = \sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i$$

$$\text{Expected reduction in number of crashes} = 1 * \frac{110}{3} * 0.60 = 22 \text{ crashes per year}$$

RECONSTRUCTION OF TEMPLE STREET, SOMERVILLE[11]

Project Need

According to the FDR, Temple Street has been a concern of the City of Somerville regarding traffic flow and safety. It is located in a high-density mix of commercial and residential buildings, with many driveways to accommodate these uses. According to the FDR, the project corridor experiences traffic delay at the intersections during peak travel hours. In addition, the sidewalks are in poor to fair condition and there are no ramps in the project area that conform to

[11] Guertin and Associates Inc., *Functional Design Report, Reconstruction of Temple Street,* Somerville, prepared for the City of Somerville and the Massachusetts Highway Department, Stoneham, Massachusetts, October, 1999.

current Americans with Disabilities Act (ADA) standards. The FDR indicates that of particular concern is the horizontal curve between Derby Street and Memorial Road—during the three-year period 1996–1998, there were 16 crashes at this location. The project would reconstruct the pavement, install ADA-compliant sidewalks, and upgrade traffic control signals and coordination to improve safety and operations for vehicular traffic, pedestrians, and bicycles.

Safety Assessment

There were 43 crashes in the 1,500-foot section of Temple Street during the three-year period 1996 through 1998. The 2004–2006 crash database shows that there were 34 crashes in same section. Crash diagrams for the 1996–1998 crashes, which are in Appendix C, show that the existing curve in the roadway between Derby Street and Memorial Road present potential hazards to motorists, especially if excessive speed or poor weather are involved. Also at the Temple Street and Heath Street intersection, vehicles departing Heath Street caused most of the crashes, when they ran through a stop sign or made an improper turn maneuver.

Crash Reduction

Table 5 shows the improvements proposed in the project for addressing safety on Temple Street and their effectiveness in reducing crashes. The 1,500-foot corridor has four closely spaced intersections. Given the closely spaced intersections and common effects of the treatments, the expected combined CRF for all the treatments in this project was calculated using Equation 1 (on page 8):

$$\begin{aligned} CRF_t &= 1 - (1 - 0.25)(1 - 0.15)(1 - 0.18)(1 - 0.09) \\ &= 1 - (0.75 \text{ x } 0.85 \text{ x } 0.82 \text{ x } 0.91) \\ &= 1 - 0.48 \\ &= 0.52\text{, or a 52\% reduction in crashes} \end{aligned}$$

TABLE 5
Reconstruction of Temple Street, Somerville:
Effectiveness of the Proposed Improvements

Improvement	Safety Need Addressed	Crash Type	Crash Severity	Crash Reduction Factor
Install new ADA-compliant sidewalks and wheelchair ramps	Reduce pedestrian-related crashes	All	All	25
Install interconnected, coordinated traffic control throughout the corridor	Reduce rear-end crashes	All	All	15
Provide pavement markings	Reduce all types of crashes	All	All	18
Implement signs to MUTCD standards	Reduce all types of crashes	All	All	9

The combined CRF estimate of 52 percent is multiplied by 0.66; this would result in a 34 percent reduction in crashes for the project area. Assuming that ADT would remain the same after treatment, the expected reduction in the number of crashes, based on the 2004–2006 crash database, was calculated using Equation 2 (on page 8):

$$\text{Expected reduction in number of crashes} = \sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i$$

$$\text{Expected reduction in number of crashes} = 1 * \frac{34}{3} * 0.34 = 4 \text{ crashes per year}$$

CENTRAL AVENUE REHABILITATION PROJECT, MILTON[12]

Project Need

According to the FDR, the intent of this project is to rehabilitate the existing roadway while providing improved pedestrian and bicycle amenities along Central Avenue. The land use along Central Avenue in the project area is primarily residential, except for Central Square area where there are small commercial businesses located on either side of Central Avenue. The FDR indicated that the concrete sidewalks have deteriorated and do not provide adequate width in accordance with MassDOT Highway Division guidelines. In addition, the existing driveway curb cuts are without standard wheelchair ramps and do not meet ADA standards.

The project would repave Central Avenue and reduce the pavement width to 35 feet in order to create a multiuse path along the east side of the street for pedestrians and bicyclists, and to reduce crossing distances to provide safety benefits for pedestrians. The existing right-of-way along Central Avenue ranges from 60 feet wide to 74 feet wide, so there would be no need for property acquisition for the proposed improvements. There is concern, however, about the excessive width of the crossing distances (44 feet) for pedestrians, particularly given the residential nature of the surrounding land use and the various neighborhoods that Central Avenue serves.

Safety Assessment

According to the current crash database, there were 39 crashes in the Central Avenue project area between 2004 and 2006. Twenty-six of the crashes occurred at the Central Avenue, Brook Road, and Reedsdale Road intersection and eight at the Central Avenue and Elliot Street intersection. The crash rates for the intersections in the project area were below the MassDOT Highway Division district averages. According to the Town of Milton, examination of collision diagrams indicated that 44 percent of the crashes were collisions with fixed objects, while 33 percent were rear-end collisions.

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[12] Town of Milton Engineering Department, Central Avenue Rehabilitation Project, Footprint Roads Program, 25% Design Submittal Report, submitted to Massachusetts Highway Department, Milton, Massachusetts, April 2006; and Beta Group Inc., "Central Avenue in Milton," technical memorandum to Philip MacDonald, Massachusetts Highway Department, August 2008.

Crash Reduction

Table 6 shows the improvements proposed in the project and their effectiveness in reducing crashes. Evaluation of the 2004–2006 crash data indicates that there were no pedestrian- or bicycle-related crashes during this period. There are no major or closely spaced intersections in the project area, and the pedestrian improvements are applied throughout the corridor. Therefore, the entire corridor is considered a single roadway segment. Using the formula for multiple treatments, the expected combined CRF of all the improvements was calculated as:

$$
\begin{aligned}
CRF_t &= 1 - (1 - 0.25)(1 - 0.18)(1 - 0.09) \\
&= 1 - (0.75 \times 0.82 \times 0.91) \\
&= 1 - 0.56 \\
&= 0.44\text{, or a 44\% reduction in crashes}
\end{aligned}
$$

The combined CRF estimate of 44 percent is multiplied by 0.66; this would result in a 29 percent reduction in crashes for the project area. Assuming that the ADT would remain the same after treatment, the expected reduction in the number of crashes, based on the 2004–2006 crash database, was calculated using Equation 2 (on page 8):

$$\text{Expected reduction in number of crashes} = \sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i$$

$$\text{Expected reduction in number of crashes} = 1 * \frac{39}{3} * 0.29 = 4 \text{ crashes per year}$$

This project enhances bicycle and pedestrian mobility to be compatible with the land use in the area. It is not intended to address a high-crash location.

TABLE 6
Central Avenue Rehabilitation Project, Milton:
Effectiveness of the Proposed Improvements

Improvement	Safety Need Addressed	Crash Type	Crash Severity	Crash Reduction Factor
Install new ADA-compliant sidewalks and wheelchair ramps	Reduce pedestrian-related crashes	All	All	25
Provide bicycle accommodations	Reduce bicycle-related crashes	Bicycle	All	36
Provide pavement markings	May reduce certain types of crashes	All	All	18
Implement signs to MUTCD standards	May reduce certain types of crashes	All	All	9

HIGHLAND AVENUE CORRIDOR IMPROVEMENTS, NEEDHAM[13]

Project Needs

According to the FDR, this project would reconstruct Highland Avenue from Webster Street to the Newton city line, excluding the Highland Avenue and I-95 interchange. The land use in the area is primarily commercial and industrial. The FDR indicated that the existing roadway in the project area is inconsistent in width, with a two-lane section west of the intersection of Highland Avenue and Gould Street/Hunting Road,, and a four-lane section east of that intersection. This inconsistency in the width of the roadway creates a bottleneck as motorists try to merge. In addition, the FDR pointed out that unprotected turns at the intersections and midblock sections by motorists accessing businesses in the area create safety problems. The modifications proposed in the project are supposed to increase capacity and improve safety and mobility through the corridor.

Safety Assessment

According to the 2004–2006 crash database, there were 103 crashes in the Highland Avenue project area. The problem intersections on Highland Avenue are: Gould Street/Hunting Road (signalized, 32 crashes), Wexford Street (unsignalized, 25 crashes), and Second Avenue (signalized, 13 crashes). Of these intersections, only the Wexford Street intersection had a crash rate that exceeded the MassDOT Highway Division average for unsignalized intersections. For the remaining intersections, the crash rates were below average and did not meet the MassDOT Highway Division thresholds for signalization.

At the intersection of Highland Avenue and Gould Street/Hunting Road, 42 percent of the crashes were angle collisions and 35 percent were rear-end collisions. According to the FDR, the main reason for the crashes could be the failure to yield to an oncoming vehicle. At the Highland Avenue and Wexford Street intersection, 86 percent of the crashes were angle collisions resulting mainly from vehicles making U-turns at the intersection. At the Highland Avenue and Second Avenue intersection, 54 percent of the crashes were rear-end and 30 percent were angle collisions. According to the FDR, a possible cause of the crashes was the absence of exclusive left-turn lanes on Highland Avenue at some of the intersections.

Crash Reduction

Table 7 shows the improvements proposed in the Highland Avenue project and their effectiveness in reducing crashes. All of the major improvements have positive average crash reduction factors. The entire project corridor was considered as two separate roadway segments, since the I-95 and Highland Avenue interchange, which was excluded from this project, separates the project into two corridors (east corridor and west corridor). Each of the corridors is about 1,500 feet long and each corridor has about five intersections. Equation 1 (on page 8) was used to calculate the combined CRF for each of the corridors and Equation 3 (on page 9) is used to calculate the expected reduction in crashes for the entire project.

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[13] Vanasse and Associates Inc., *Functional Design Report, Highland Avenue Corridor Improvements,* prepared for the Town of Needham, Massachusetts, Andover, MA, August 2002.

TABLE 7
Highland Avenue Corridor Improvements, Needham:
Effectiveness of the Proposed Improvements

Improvement	Safety Need Addressed	Crash Type	Crash Severity	Crash Reduction Factor
Widen Highland Avenue to two lanes from Gould Street/Hunting Road to Webster Street *(west corridor).*	May reduce certain types of crashes	All	All	10
Install fully actuated traffic signal controller at Wexford Street intersection *(east corridor)*	Reduce left- and right-turn related crashes	Left turn	All	80
Install left-turn lane and phase on Highland Avenue and Wexford Street *(east corridor)*	Reduce left-turn related crashes	All	All	58
Install interconnected, coordinated traffic control *(east corridor)*	Reduce stops and hence rear-end crashes	All	All	15

West Corridor
For the west corridor, there is only one proposed improvement (widen Highland Avenue to two lanes in each direction from Gould Street/Hunting Road to Webster Street), shown in Table 7. The CRF for this type of improvement is 10 percent. The CRF for the west corridor was not reduced by 0.66, because it is a single treatment and would not have the same effect as multiple treatments.

East Corridor
For the east corridor, there are three proposed improvements, described in Table 7. Improvements in this corridor have multiple-treatment effects. The expected combined CRF for all the treatments in the east corridor was calculated using Equation 1 (on page 8).

$$\begin{aligned} CRF_t &= 1 - (1 - 0.80)(1 - 0.58)(1 - 0.15) \\ &= 1 - (0.2 \times 0.42 \times 0.85) \\ &= 1 - 0.07 \\ &= 0.93\text{, or a 93\% reduction in crashes} \end{aligned}$$

The crash reduction estimate of 93 percent, derived using the above equation, was multiplied by 0.66, resulting in a 61 percent reduction in crashes for the east corridor.

Assuming that the ADT would remain the same after treatment in both west and east corridors, the expected reduction in the number of crashes, based on the 2004–2006 crash database, was calculated using Equation 3 (on page 9):

Expected reduction in number of crashes $= \sum_j \left[\sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i \right]$

Expected reduction in number of crashes $= (1 * \frac{38}{3} * 0.1) + (1 * \frac{65}{3} * 0.61)$

Expected reduction in number of crashes = 1 + 13 = 14 crashes per year

ROUTE 139 (PLAIN STREET) CORRIDOR IMPROVEMENTS, MARSHFIELD[14]

Project Need

According to the FDR, this project proposes transportation improvements on Route 139 between the School Street and Furnace Street intersections, a distance of approximately one mile. The FDR indicated that the existing roadway section (midblock) in the project area is inconsistent with the sections at the intersections, creating merging and bottlenecks that cause traffic delays and queues. In addition, the FDR indicated that Route 139 has only one sidewalk on the south side; hence, pedestrians on the north side must walk either in the grassy areas or in the shoulder. The project proposal consists of a four-lane section (with turn lanes at major intersections) and sidewalks to provide needed consistency, reduce traffic delay and queues, improve pedestrian safety, and be ADA-compliant.

Safety Assessment

Table B-3 (in Appendix B) shows the 2001–2003 crash frequencies and rates for the Route 139 project. Along the Plain Street corridor, during the 2004–2006 period, there were 116 crashes along the one-mile corridor at intersections and at non-intersection locations or driveways. This is an average of approximately 39 crashes per year. Approximately 28 percent of these were angle crashes, while 37 percent were rear-end. More than half resulted in property damage, and 25 percent involved personal injury. No fatalities were reported.

There are three major intersections in the one-mile project area. At the School Street and Plain Street intersection, there were 12 crashes during the 2004–2006 period; the crash rate, which was calculated to be 0.34, falls below the MassDOT Highway Division district average. At the intersection of Enterprise Drive and Plain Street, there were 27 crashes during the 2004–2006 period; the crash rate for this intersection was 0.85, which exceeded the MassDOT Highway Division average. The intersection of Furnace Street and Proprietor's Way at Plain Street experienced 18 crashes during 2004–2006 period; the crash rate for this intersection was calculated to be 0.51, which falls below the MassDOT Highway Division average.

[14] Tetra Tech Rizzo, *Functional Design Report,* Plain Street (Route 139), Marshfield, Massachusetts, submitted to Massachusetts Highway Department, December 2007.

Crash Reduction

Table 8 shows the improvements proposed in the Plain Street project and their effectiveness in reducing crashes. Because the major improvement (widening to four lanes from two lanes) was to be applied throughout the corridor, it made sense to treat the entire project corridor as a single roadway segment. Using the Equation 1 (on page 8) for multiple treatments, the combined CRF of all the improvements was calculated as:

$$\begin{aligned} CRF_t &= 1 - (1 - 0.10)(1 - 0.09)(1 - 0.22)(1 - 0.15)\ , \\ &= 1 - (0.90 \times 0.91 \times 0.78 \times 0.85) \\ &= 1 - 0.54 \\ &= 0.46 \text{ or a 46\% reduction in crashes} \end{aligned}$$

The combined CRF estimate of 58 percent is multiplied by 0.66; this would result in a 30 percent reduction in crashes for the project area. Assuming that the ADT would remain the same after treatment, the expected reduction in the number of crashes, based on the 2004–2006 crash database, was calculated using Equation 2 (on page 8):

TABLE 8
Route 139 (Plain Street) Corridor Improvements, Marshfield:
Effectiveness of the Proposed Improvements

Improvement	Safety Need Addressed	Crash Type	Crash Severity	Crash Reduction Factor
Widen Plain Street to four lanes in the project area	Reduce rear-end crashes	All	All	10
Install six-foot shoulders on both sides of Plain Street	Reduce crashes between single vehicle and fixed object	All	All	9
Install fully actuated traffic signal controller at Plain Street and Furnace Street intersection	Reduce left- and right-turn-related crashes	Left turn	All	80
Install interconnected, coordinated traffic control throughout the corridor	Reduce rear-end crashes	All	All	15

$$\text{Expected reduction in number of crashes} = \sum_i \frac{ADT_a}{ADT_b} * N_b * CRF_i$$

$$\text{Expected reduction in number of crashes} = 1 * \frac{116}{3} * 0.30 = 12 \text{ crashes per year}$$

RESULTS OF THE EVALUATION

The results of the safety evaluations are presented in Table 9. The combined crash reduction (CRF) factors were used to calculate the effectiveness in reducing crashes of the proposed improvements in each project. The expected reduction in crashes is directly related to the number of crashes before treatment and the combined crash reduction factor. For project evaluation and selection purposes, both the combined crash reduction factor and the expected reductions in crashes should be considered. For example, the Trapelo Road and Belmont Street Corridor Improvements and Route 53 (Washington Street)/Middle Street projects have high combined crash reduction factors and, when constructed, they are expected to improve safety significantly. Both locations are included in the top five percent of intersection clusters for the Boston Region MPO area. The Route 53 (Washington Street)/Middle Street project is also in the top 200 intersection crash clusters for Massachusetts. These thresholds are part of the project selection criteria for the Highway Safety Improvement Program (HSIP) for reducing the number of fatal and injury crashes by targeting high-crash locations.

TABLE 9
Estimated Project Safety Impacts

Project	Location	Project Length (miles)	Number of Crashes in Project Area (2004–2006)	Combined Crash Reduction Factor (%)	Expected Reduction in Crashes (per year)	Expected Annual Reduction in Crashes (per Mile)
Trapelo Road and Belmont Street Corridor Improvements	Belmont	2.6	317	52	55	21
Route 53 (Washington Street)/Middle Street	Weymouth	Intersec tion	110	60	22	22
Route 16 Traffic Signal Improvements	Milford	1.5	142	40	19	13
Highland Avenue Corridor Improvements	Needham	0.7	103	41	14	20
Route 139 (Plain Street) Corridor Improvement Study	Marshfield	1.0	116	30	12	12
Reconstruction of Temple Street	Somerville	0.3	34	34	4	13
Central Avenue Rehabilitation Project	Milton	0.9	39	29	4	4

FINDINGS

1. The methodology developed and applied by MPO staff to evaluate the safety potential of TIP projects is sound. However, the national crash reduction factors (CRF) used in the analysis are not reliable. There are some concerns about the national CRFs used in this study regarding their transferability and the reliability of the research supporting them.

   - A review of the literature indicated that some states, such as California, are unwilling to employ national CRFs that have not been proven and validated with appropriate research and are adopting a wait-and-see approach. Florida has created its own CRFs but they are not available for public review. Other states, such as Kentucky, Texas, Oregon, and Washington, use the national CRFs to augment their locally developed CRFs when the national CRFs are deemed appropriate and are adequately supported by research. Minnesota is one of the states that use the Desktop Reference as its primary source of CRF data.

   - State and local jurisdictions with reliable and locally developed CRFs employ them in the following applications:

     - Estimating crash reductions associated with highway safety design elements—for example, measuring the safety effectiveness of various improvements in order to design and implement those that are most effective.

     - In program planning for deciding whether to implement a specific treatment and/or to quickly determine the costs and benefits of selected alternatives.

2. Several problems that were encountered in this pilot study need to be considered:

   - Functional design reports (FDRs) were not readily available to MPO staff, and it took some time to obtain them.

   - Some of the FDRs do not contain sufficient safety information for determining whether proposed improvements would address existing safety needs (for example, some contain only crash frequencies and rates). Additional safety information, such as collision diagrams, may be needed.

   - Using the CRF approach to evaluate safety improvements requires identifying safety needs, analyzing crash data, obtaining and applying CRFs, and evaluating how proposed improvements would address safety needs. It involves more quantitative analysis and requires more time than the method currently used by the Boston Region MPO. Consequently, it is expected to cost more to implement.

     The efforts expended in this study cost $25,100, and about half of that amount was spent for the seven intersections that were evaluated. This represents an average cost of $1,800 per project. By comparison, the cost per project of the approach currently used by the MPO, which evaluates safety based on rankings of crash rates and equivalent property damage only (EPDO), is significantly lower.

RECOMMENDATION

Accurate CRFs are required in order to achieve the greatest return on safety investments when choosing among alternative treatments. The national CRFs contained in the Desktop Reference,[15] which was used in this study, were collected from many studies in several different states. Its use raises concerns regarding: origin and transferability, methodological issues, and lack of information on effectiveness. Massachusetts has not developed a comprehensive CRF database for use in the commonwealth, so these issues may need to be addressed.

In closing, MPO staff consider using the crash reduction factor for TIP project evaluation to be a sound method, but they have reservations about recommending its adoption by the Boston Region MPO because the national data appear to inadequately represent local conditions. In addition, the cost of analysis associated with this method is higher than the cost of the method currently used by the Boston Region MPO.

EP/SAA/saa

[15] *Desktop Reference for Crash Reduction Factors*, U.S. Department of Transportation, Federal Highway Administration, Publication No. FHWA-SA-07-015, September 2007.

APPENDIX A

List of Projects and Other Information

KEY
Blue denotes project's FDR is available to staff.
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White denotes project's FDR is unavailable to staff.

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List of TIP Projects and Other Information

Project ID	Project Name	Municipality	MassDOT Highway Division District	Design Status	Project Manager (Phone Extension)	Project Description	Project Need	Top 200 Intersection Clusters (Massachusetts)	Top 5% Intersection Clusters (Boston Region MPO area)	Equivalent Property Damage Only (EPDO)	Reported Crash Data	Recommended Safety Improvements	Date Report was Received	FDR at CTPS	CTPS Comment
604957	Route 14 Corridor	Pembroke	5	25% Submitted	Adam Hoey (7440)	Reconstruction, widening, drainage improvements, and related work on Route 14, from Route 53 to the Hanson town line.	The existing geometry along the Route 14 corridor project creates safety deficiencies and operations problems at certain locations. In addition, existing traffic signage and striping are in poor condition and the sidewalks are not continuous. The proposed roadway improvements would enhance safety and traffic flow.	No	Yes	Multiple locations EPDO = 148 Fatal = 0 Injury = 19 PDO = 53	2003-2005 No collision diagram	Roadway widening, sidewalks, curbing, signage, pavement markings, and drainage upgrades	12/9/2008	Yes	Called Dec. 5 and left message. Expediter has FDR. Received on December 9.
604688	Trapelo Road and Waltham Street	Belmont	4	25% Submitted	Albert (Al) Miller (7862)	Reconstruct Trapelo Road and Belmont Street from the Cambridge city line to the Waltham city line.	The project corridor experiences excessive traffic delays at certain intersections and the closely-spaced signalized intersections are not interconnected and coordinated for efficient traffic operations. Safety is an issue in the corridor for both pedestrians, bicyclists, and motorists. The proposed improvements would update signals and timings and improve roadway conditions to accommodate increased traffic volumes, improve pedestrian access, and provide bicycle accommodation.	No	Yes	Multiple locations EPDO = 665 Fatal = 0 Injury = 86 PDO = 231	2003-2005 With collision diagram	New traffic signals, bicycle accommodation, and drainage	12/9/2008	Yes	Called Dec. 5 and left message. Received FDR on December 9.
29492	Middlesex Turnpike/Crosby Drive Roadway Improvements Project, Phase 3	Bedford, Billerica, and Burlington	4	75% Submitted	Albert (Al) Miller (7862)	Widen Middlesex Turnpike from north of Crosby Drive from its two-lane cross section to a four-lane section having two lanes in each direction with a 16-foot median with left-turn lanes and signals at high-volume driveways and intersections.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Widening, left-turn lanes, signalization, median	No report received	No	Left message on Dec. 5. Expediter will search files for FDR.
604646	Route 62 (Main Street)	Concord		75% Submitted		Reconstruct Main Street from Water Street to Acton town line.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Install granite curbs, addition of sidewalk, and drainage upgrade	No report received	No	Left message on Dec. 5. This project was advertised for construction. 100% design submitted and approved.
604344	Needham Street	Newton	4	25% Submitted	Anyinla Madamidola (7361)	Needham Street Rehabilitation, from Needham town line to Winchester Street and Winchester Street from Needham Street to Route 9. The roadway will be rehabilitated and widened to accommodate bicycles. The project includes new sidewalks, reconfigured intersections.	The Needham Street project is justified for three major reasons. Existing geometry along the corridor causes excessive delay and safety deficiencies. The proposed modifications—signal installations and geometric improvements—would increase capacity and improve mobility through the corridor.	No	Yes	Multiple locations EPDO = 188 Fatal = 0 Injury = 27 PDO = 116	1998-2000 No collision diagram	Roadway widening, bicycle accommodation, new sidewalks, reconfigured intersections, revised traffic signals	12/5/2008	Yes	Called on Dec. 5. Received FDR on Dec. 5.
602053	Intersection Improvements at 3 Locations	Watertown		75% Submitted		Make intersection improvements at three locations: Arlington Street, Nichols Avenue, Coolidge Hill Road, and Crawford Street; Spring Street and Summer Street; and Mount Auburn Street and Summer Street.	The three locations in this project have safety and operational problems in terms of high crash rates and excessive traffic delays. The installation of traffic signals at two of the locations and a four-way stop control at a third location would improve safety. Geometric improvements, relocation of curb cuts, and roadway realignment are expected to improve both safety and operations.	No	No	Multiple locations EPDO = 92 Fatal = 0 Injury = 9 PDO = 47	1999-2001 No collision diagram	4-way stop control Traffic signal installations Roadway alignment Sidewalk/curbing/ramps	12/5/2008	Yes	25% in 2002. 75% in 2005. See if CTPS can get FDR from Watertown.
603462	Route 53/Winter Street	Duxbury	5	25% Submitted	Brian Chapman (7265)	Make improvements to the intersection of Route 53 and Winter Street.	At Route 53 and Winter Street, the high number of crashes involving cross-movement, rear-end, or head-on collisions is due to the flashing beacon controlling traffic operations at the intersection. The proposed fully actuated traffic control signal would reduce crashes and increase safety.	No	No	Multiple locations EPDO = 7 Fatal = 0 Injury = 0 PDO = 7	1999-2001 No collision diagram	New traffic signal Geometric improvements	12/5/2008	Yes	Called Dec. 5. Received FDR on Dec. 5
602639	Route 138 (Blue Hill Avenue) - Neponset Valley Parkway	Milton	4	25% Submitted		Upgrade the traffic signals at the intersection of Route 138 (Blue Hill Avenue) and Neponset Valley Parkway.	This intersection experiences excessive traffic delay during the AM peak on Neponset Valley Parkway, and it is also overrepresented in nighttime crashes (70%). The proposed traffic control signal and addition of a left-turn lane on Blue Hill Avenue would improve safety and traffic operations.	No	Yes	Single locations EPDO = 44 Fatal = 0 Injury = 7 PDO = 9	2001-2003 No collision diagram	New traffic signal Geometric improvements Drainage improvements Signs/pavement markings	12/5/2008	Yes	Called Dec. 5. Received FDR on Dec. 5
604811	East Main Street	Marlborough	3	25% Submitted	Carrie Lavallee (8834)	Reconstruct Route 20 (East Main Street)	The project is proposed in order to address concerns regarding the current substandard condition of the roadway and sidewalks to address demands associated with current and future projections. The reconstruction, in addition to minor changes in alignment, traffic management, sidewalk reconstruction, and curb replacement, would address this need.	No	Yes	Multiple locations EPDO = 135 Fatal = 0 Injury = 14 PDO = 65	None	Resurfacing	12/9/2008	No FDR; just design submission	Called Dec. 5 and left message. FDR in Projis file? Expediter can not send PDF. We may need to get a hard copy. Received 25% design submission on December 9.
604915	Route 139 Corridor Improvements	Marshfield	5	25% Submitted		Reconstruct Route 139	The existing roadway section in the project area is inconsistent. The sections at the intersections create merging and bottlenecks that cause traffic delays and queues. The proposed four-lane section and sidewalks would provide needed consistency and reduce traffic delay and queues, as well as improving pedestrian safety and achieving ADA compliance.	No	Yes	Multiple locations EPDO = 365 Fatal = 0 Injury = 40 PDO = 155	2003-2005 No collision diagram	Widening, geometric improvements, and sidewalks,	12/9/2008	Yes	FDR in Projis file? We may need to get a hard copy. Received FDR on December 9.
605122	Clippership Drive Reconstruction	Medford	4	25% Submitted		Improvements and realignment on Clippership Drive	The proposed project is Phase I of the Medford Square Master Plan to create a single identity for the Square, encourage mixed-use vibrancy, develop the pedestrian character, and balance transportation modes. The proposed project would narrow the roadway from two travel lanes to one travel lane and one parking lane; realign the roadway away from the Mystic River to expand parkland; and create a sidewalk on the north side of Clippership Drive.	No	No	Multiple locations EPDO = 37 Fatal = 0 Injury = 4 PDO = 19	2004-2006 No collision diagram	Roadway realignment Sidewalks/granite curbing Traffic calming	12/9/2008	Yes	FDR in Projis file? We may need to get a hard copy. Received FDR on December 9.
600219	Cabot Street	Beverly		25% Submitted		Reconstruct Cabot Street from Rantoul Street to Roosevelt Avenue. Work on this project includes traffic signals, sidewalks, drainage.	Cabot Street experiences excessive traffic delay and safety problems in the project area. The proposed reconstruction includes modifications that would increase safety and improve traffic flow.	No	Yes	Multiple locations EPDO = 437 Fatal = 0 Injury = 53 PDO = 172	1989-1991 No collision diagram	Minor widening Roadway realignment Signal upgrade, Turning lanes	12/8/2008	Yes	Town wishes to merge this and project below. From eight years ago, design may actually be at 75% or 100% but needs to be brought back to 25% as regulations have changed. No contract at present. Expediter will find FDR (DEC. 5) and call on week of Dec. 8. Received on December 8.

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Project ID	Project Name	Municipality	MassDOT Highway Division District	Design Status	Project Manager (Phone Extension)	Project Description	Project Need	Top 200 Intersection Clusters (Massachusetts)	Top 5% Intersection Clusters (Boston Region MPO area)	Equivalent Property Damage Only (EPDO)	Reported Crash Data	Recommended Safety Improvements	Date Report was Received	FDR at CTPS	CTPS Comment
600220	Route 1A (Rantoul Street)	Beverly	4	25% Submitted	Filbert Yee (7883)	Reconstruct and re-signalize Route 1A (Rantoul Street) from Cabot Street (South) to Cabot Street (North).	Rantoul Street experiences excessive traffic delay and safety problems in the project area. The proposed reconstruction include modifications that would increase safety and improve traffic flow.	No	No	Multiple locations EPDO = 30 Fatal = 0 Injury = 4 PDO = 10	1992-1994 No collision diagram	Add turn lanes Traffic signal upgrade Sidewalk/curbing/ramp	12/8/2008	Yes	None
601821	Temple Street	Somerville		25% Submitted		Reconstruct Temple Street from Broadway to Mystic Avenue.	Temple Street has been a concern of the City of Somerville regarding traffic flow and safety. The project corridor experiences long traffic delays at the intersections during peak travel hours. The project modifications, including pavement reconstruction, ADA-compliant sidewalks, traffic control signal reconstruction, and signal coordination, would improve operations and safety for vehicular traffic, pedestrians, and bicyclists.	No	Yes	Multiple locations EPDO = 74 Fatal = 0 Injury = 10 PDO = 24	1996-1998 With collision diagram	Roadway reconstruction Sidewalks/granite curbing Signs/pavement markings Drainage improvements	12/8/2008	Yes	Expediter will find FDR (Dec. 5) and call week of Dec. 8. Received on December 8.
602496	Route 115 (Pond/Pine Streets), Route 140	Foxborough, Norfolk, & Wrentham	5	75% Submitted	Gautam Sen (7889)	Reconstruct Route 115 (Pond Street and Pine Streets) from Needham Street in Norfolk to Route 140 in Foxborough.	Traffic safety and operations concerns in the corridor	No	No	n/a	n/a	Safety Improvements	12/10/2008	Yes	Called Dec. 5 and left message.
602078	Route 62 (Maple Street)	Middleton	4	25% Approved	Joseph Mumbrun (7876)	Reconstruct Route 62 (Maple Street) from Washington Street to the Ipswich River.	Project report unavailable to staff	No	No			Reconstruction	No report received	No	Called on Dec. 5. No FDR. Last correspondence June 2005 from Louis Berger about constructing sidewalk.
601553	Lebanon & Main Streets	Melrose		25% Submitted	Joseph Mumbrun (7876)	Reconstruct Lebanon Street and Main Street and upgrade signals.	The existing roadway in the project area has inadequacies as well as traffic safety and operational deficiencies. The proposed improvements include roadway and sidewalk rehabilitation, signal upgrade, new signs and pavement markings, and geometric improvement to address these deficiencies.	No	Yes	Multiple locations EPDO = 193 Fatal = 0 Injury = 32 PDO = 33	2003-2005 No collision diagram	Resurfacing, minor widening, sidewalks, wheelchair ramps, signal modifications and upgrades, pedestrian signal phasing, and crosswalk improvements	12/10/2008	Yes	Called on Dec. 5. Called Darshan Jhavris of Beta Group to get FDR (781-255-1982). 75% design is under review by MassDOT Highway Division. The District already reviewed 75% design. Beta Group will send a PDF of the FDR on Dec. 9.
601274	Tremont Street, Phase 1	Boston	4	25% Submitted	Kimberly (Kim) Sloan (7495)	Reconstruct Tremont Street from Court Street to Boylston Street.	Tremont Street experiences excessive delay currently, and it is expected to worsen in the future if improvements are not implemented. The proposed project would improve the existing geometric layout, upgrade traffic control signals, and install an interconnected cable system. The project would also improve lighting, signage, and striping.	No	No	Multiple locations EPDO = 110 Fatal = 0 Injury = 14 PDO = 40	1998-2000	Traffic signal upgrades, sidewalks/wheelchair ramps, signage, and pavement markings	12/5/2008	Yes	Called Dec. 5 and left message. Received FDR on Dec. 5.
600636	Massachusetts Avenue	Boston	4	75% Submitted	Kimberly (Kim) Sloan (7495)	Reconstruct Massachusetts Avenue from Westland Avenue to Albany Street.	Project report unavailable to staff	n/a	n/a	n/a	n/a	New lighting, urban design treatments, sidewalks and wheelchair ramps	No report received	No	Called Dec. 5 and left message. Project is 100% approved; opening bids soon.
600283	North Street	Foxborough	5	25% Approved	Manhar Patel (7217)	Reconstruct North Street from Route 1 to Route 140, and improve intersections, sidewalks, and drainage.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Sidewalks, wheelchair ramps, traffic signal installation, and signage, and pavement markings	No report received	No	Called Dec. 5. Project may be dropped; waiting to hear from District 5.
601705	West Street	Reading	4	75% Submitted	Manhar Patel (7217)	Reconstruct West Street from the intersection of Summer Avenue and Willow Street to the Woburn city line, including: signalization of three intersections, installation of a pedestrian signal, resurfacing the roadway, and installation of sidewalk and curb.	The project area along West Street has safety-deficient locations and operational problems, including, but not limited to, excessive traffic delays, absence of sidewalks and ADA-compliant street elements, and inconsistent roadway sections. The proposed modifications would provide consistent roadway cross sections, sidewalks for pedestrians, and accessible pedestrian facilities. It would also provide geometric improvements, interconnect existing signals, and provide new signals to improve safety and operations.	No	No	Multiple Locations EPDO = 61 Fatal = 0 Injury = 6 PDO = 31	2001-2003 No collision diagram	New sidewalks/curbing, drainage, and new traffic signals	12/8/2008	Yes	Expediter will get FDR week of Dec. 8. Received on December 8.
603134	Route 37 (Granite Street) at I-93	Braintree	4	75% Submitted	Manhar Patel (7217)	Reconstruct the I-93 northbound off-ramp to Granite Street (Route 37) and construct a new ramp (off the existing ramp) to connect to Forbes Road. Forbes Road will be connected to a relocated portion of Brooks Drive.	Project report unavailable to staff	n/a	n/a	n/a	n/a	New ramps and access improvements	No report received	No	Project was suspended.
601359	Pleasant Street	Franklin	3	75% Submitted	Manhar Patel (7217)	Reconstruct Pleasant Street from Main Street to Chestnut Street.	The Pleasant Street project area has operational deficiencies that impact safety in this corridor, including but not limited to poor geometry and sight distances, lack of turn lanes and crosswalks and handicap facilities, poor or substandard pavement, excessive delays, and drainage problems. The proposed improvements, consisting of exclusive turn lanes, signal upgrades and coordination, and improved sight distance, would address these deficiencies and improve safety and operations.	No	No	Multiple Locations EPDO = 67 Fatal = 0 Injury = 10 PDO = 17	1994-1996 No collision diagram	Shoulder widening, curbing, new traffic signal, signal upgrades, sidewalks, wheelchair ramps, signage, and pavement markings	12/8/2008	Yes	Expediter will get FDR week of Dec. 8. Received on December 8.
602081	Route 107 (Western Avenue)/Eastern Avenue	Lynn	4	25% Submitted	Marie Rose (7427)	Improve the intersection of Route 107 (Western Avenue) and Eastern Avenue.	Project report unavailable to staff	n/a	n/a	n/a	n/a	New traffic signal	No report received		Project in pre-25% design
6870	Boundary Street	Marlborough & Northborough	3	25% Submitted	Michael Papadopoulos (7356)	Reconstruct Boundary Street from Route 20 (West) to Goddard Road.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Realignment	No report received	Project inactive	Project inactive. It has been in pre-25% design since 1998. Northborough may not have had money to continue with design. There has been no 25% design public hearing.

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602378	Route 123	Norwell	5	25% Submitted	Michael-kosmas (Mike) Bloukos (7333)	Reconstruct Route 123 from just west of Dover Street to the Scituate town line.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Roadway alignment, sidewalks, wheelchair ramps, curbing, drainage, signage, and pavement markings	No report received	Project Suspended	Called Dec. 5 and left message. Project is from the 90s. At 25% hearing 3-4 years ago, there was opposition to the project that caused it to stall. Residents opposed to sidewalks and widening. They may want to resume project under principles of new Design Guidebook.
602382	Route 99 (Broadway)	Everett	4	25% Submitted	Muazzez Reardon (8437)	Reconstruct Route 99 (Broadway) from Sweetser Circle to the Boston city line at the traffic signals.	Broadway Street serves as a commuter route to other major highways north and south of Boston. This high travel demand, coupled with the intense parking and trucking activities, has caused traffic on Broadway to deteriorate, resulting in cut-through traffic in nearby residential areas. The proposed modifications reduce the peak-period congestion as well as cut-through traffic.	No	Yes	Multiple locations EPDO = 343 Fatal = 0 Injury = 52 PDO = 83	2003-2006 No collision diagram	Traffic signal upgrades	12/15/2008	Yes	Call last. Called Muazzez on Friday and left a message. Received the FDR on Monday, December 15.
114501	Route 53, Phase 1B	Hanover	5	75% Approved (100% design, under construction 40%, complete)	Peter Benkart, District 5	Widen Route 53 from two lanes to five lanes (two lanes in each direction with a bidirectional center turning lane) from Mill Street to Pond Street. In addition, Pond Street will be realigned to form a four-way intersection with Washington Street.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Widening (2 to 5 lanes), bidirectional center turn lane, intersection realignment	No report received	No	Under construction
604664	Quincy Center Concourse, Phase 2	Quincy	4	75% Submitted	Phillip McDonald (7552)	Construct the "East Side Link" of the Quincy Center Concourse. This project includes the construction of a roadway link between the "West Side Link" (Phase 1 of the project) and Mechanic Street, and Revere Road.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Roadway resurfacing, sidewalks, curbing, new traffic signals, and new alignment	No report received	No	Called Dec. 5 and left message. Waiting for District 4 75% comments. Will speak on Dec. 8 on getting the FDR. 75% traffic plans approved, 75% highway design awaiting approval.
604206	Central Avenue	Milton	4	25% Submitted	Phillip McDonald (7552)	Reconstruct Central Avenue from Brook Road to Eliot Street. The project includes roadway resurfacing, drainage improvements, signs, and pavement markings. Also included is the creation of a two-way multiuse path.	The intent of this project is to rehabilitate the existing roadway, providing improved pedestrian and bicycle amenities along Central Avenue.	No	Yes	Multiple locations EPDO = 79 Fatal = 0 Injury = 10 PDO = 29	2000-2002 With collision diagram	Drainage improvements, signage, and pavement markings	12/18/2008	Yes	Called Dec. 5 and left message. Will speak on Dec. 8 about getting the FDR. Received the FDR on Friday, December 18.
601820	Beacon Street	Somerville	4	75% Submitted	Shawn Holland (7242)	Reconstruct Beacon Street from Oxford Street to the Cambridge city line.	Project report unavailable to staff					New sidewalks, granite curbing, traffic signal improvements, and drainage	No report received	No	Called Dec. 5 and left message. Expediter does not have FDR. We need to call him so that he gets it from consultant or the City. Dec. 9: Expediter will call Charlie O'Brien, city engineer, to get a copy.
601704	Walnut Street	Newton		25% Submitted		Reconstruct Walnut Street from Homer Street to Centre Street, upgrade the signalization, and improve the drainage. This project also includes improvements to the Centre Street intersection from 100 feet east of Walnut Street to Route 9.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Traffic signal upgrades and reconstruction	No report received	No	
601017	Route 1A (Bridge Street)	Salem		25% Submitted		Reconstruct Route 1A (Bridge Street) from the Veterans' Memorial Bridge to Washington Street.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Sidewalk, wheelchair ramps, signage, and pavement markings	No report received	No	
5399	Bridge Street (Beverly/Salem Bridge)	Salem	4	25% Submitted	Steven McLaughlin (7245)	Reconstruct Bridge Street from Flint Street to Washington Street. Bridge Street will be widened from two to four travel lanes between Flint Street and the North Street interchange ramps. The project will also include new sidewalks and curbing.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Roadway widening, sidewalks, wheelchair ramps, curbing, drainage, and street lighting	No report received	No	25% was submitted and rejected. Expediter will get FDR, Dec. 5. Called Steven on December 15; he is still awaiting FDRs.
602984	Route 2 (Crosby's Corner)	Concord & Lincoln		75% Submitted		The purpose of this project is to provide safety improvements at Crosby's Corner (intersection of Route 2, Cambridge Turnpike, and Route 2A/Concord Turnpike). This will be accomplished by constructing neighborhood service roads to safely and efficiently accommodate traffic and to provide safe access to the residences and businesses located along the project corridor.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Limited-access-highway improvements	No report received	No	
601899	Commonwealth Avenue (Route 30), Phase 3	Newton		75% Submitted		Reconstruct Route 30 (Commonwealth Ave.) from Grant Avenue to the Boston city line.	Project report unavailable to staff	n/a	n/a	n/a	n/a	New sidewalks, granite curbing, and traffic signals	No report received	No	
601513	Route 1/Walnut Street	Saugus	4	75% Approved	Thomas Currier (7244)	Reconfigure the Route 1 and Walnut Street interchange by channeling all vehicles exiting from Route 1 onto a separate northbound or southbound exit ramp. Also, install traffic signals, consolidate driveways, eliminate sidewalks, and widen Walnut Street.	Safety concerns at the Route 1/Walnut Street interchange prompted improvements at the interchange and vicinity. The modifications proposed address both safety and operations.			Multiple Locations EPDO = 374	2002-2005 Collision diagram	Ramp modifications New traffic signals Interconnection of four traffic signals	12/10/2008	Yes	Called December 10. Tom said there are minor updates to this project and it is almost at 100%. FDR received.
602133	Route 2A and Waltham Street	Lexington	4	25% Submitted		Upgrade the signalization at the intersection of Route 2A and Waltham Street.	This intersection of Route 2A at Waltham Street experiences excessive traffic delay during the AM peak, and it is also overrepresented in crashes (1.53 crashes per MEV). The proposed geometric changes and traffic control signal upgrades and improvements to facilitate pedestrian movement and safety would address these needs.	No	Yes	Multiple Locations EPDO = 98 Fatal = 0 Injury = 14 PDO = 28	1999-2001 No collision diagram	Traffic signal improvements New traffic signal Sidewalks/wheelchair ramps Signs/pavement markings	12/10/2008	Yes	75% design submitted, FDR received on December 10.

KEY
Blue denotes project's FDR is available to staff.
Yellow denotes project is suspended, tabled, dropped, pre-25% design status, or 100% design submitted.
White denotes project's FDR is unavailable to staff.

TABLE A-1
List of TIP Projects and Other Information

Project ID	Project Name	Municipality	MassDOT Highway Division District	Design Status	Project Manager (Phone Extension)	Project Description	Project Need	Top 200 Intersection Clusters (Massachusetts)	Top 5% Intersection Clusters (Boston Region MPO area)	Equivalent Property Damage Only (EPDO)	Reported Crash Data	Recommended Safety Improvements	Date Report was Received	FDR at CTPS	CTPS Comment
603867	Route 16 Signal Improvements	Milford	3	25% Submitted	Thomas Currier (7244)	This project begins at the intersection of Route 16 and Route 85 and Middleton Street, continuing southward along Route 16 approximately 1.5 miles to the intersection of Route 16, South Main Street, Congress Street, and Water Street. Seven traffic signals will be retimed, interconnected, and coordinated.	Route 16 corridor in the project area is not operating efficiently, as it experiences excessive traffic delay, a higher than expected number of crashes, and pedestrian mobility problems. All of the seven traffic signal controls are missing essential signal equipment or are currently using outdated signal equipment, resulting in less than optimal operational conditions. The proposed improvements would establish fully optimized signal operations and improve safety along the corridor to allow safe and efficient traffic flow while addressing pedestrian needs.	No	No	Multiple locations EPDO = 292 Fatal = 0 Injury = 33 PDO = 127	2002-2005 With collision diagram	Traffic signal retiming, interconnected signal coordination, and signal equipment upgrade	12/10/2008	Yes	Project is advancing to 75% design. FDR received on December 10.
601827	Highland Avenue	Needham	4	25% Submitted		Reconstruct Highland Avenue from Webster Street to the Newton city line.	The Highland Street project is justified for the following reason: existing geometry along the corridor causes excessive delay and safety deficiencies. The proposed modifications: signal installations and geometric improvements would increase capacity and improve mobility through the corridor.	No	Yes	Multiple Locations EPDO = 208 Fatal = 0 Injury = 21 PDO = 103	1998-2000 No collision diagram	Roadway widening, exclusive left-turn lanes, sidewalks, curbing, new traffic signals/upgrades, signage, pavement markings, and bicycle accommodation	12/10/2008	Yes	Project was delayed because of opposition from the towns. The District is working with them to resurrect the project. FDR received on December 10.
114906	Route 53 (Washington Street) and Middle Street	Weymouth	4	75% Submitted		Make safety improvements at the intersection of Route 53 (Washington Street) and Middle Street and Winter Street. The road will be widened and new sidewalks, signs, and pavement markings will be installed.	This intersection is not only operating with excessive delays, but also has safety deficiencies. The existing traffic control system is old and outdated. The need therefore exists to upgrade the traffic control signal system and implement geometric improvements to address pedestrian and traffic safety at the intersection.	Yes	Yes	Single locations EPDO = 214 Fatal = 0 Injury = 55 PDO = 104	1990-1992 With collision diagram	Traffic signal improvements, new traffic signals, widening, new sidewalks, signage, and pavement markings.	12/10/2008	Yes	FDR received on December 10.
602012	Chestnut Street	Needham	4	25% Approved	Tracy Wu (7556)	Reconstruct Chestnut Street.	The project area along Chestnut Street lacks pedestrian amenities, such as sidewalks, and the drainage system is in poor condition at some locations, as are the existing traffic signage and striping. Sections of Chestnut Street have substandard design and excessive traffic delays. The proposed modifications would address these deficiencies to improve safety and traffic flow. They include geometric improvements, widening, sight distance improvements, additional signing and striping, sidewalks, and a new fully actuated traffic control signal.	No	Yes	Multiple locations EPDO = 155 Fatal = 0 Injury = 22 PDO = 45	1996-1998 No collision diagram	Roadway widening, sidewalks, curbing, new traffic signals, signage, and pavement markings	12/10/2008	Yes	Called Dec. 5 and left message. Project at 25%, approved as of 3 years ago. There is a safety and design report that we can get from Tracy on Monday, December 8. Call first. Received FDR on December 10. Project is now at 75%, but it has been stalled for some time.
604812	Route 85/Washington Street	Hudson	3	25% Submitted	Victoria Sheehan	Reconstruct Route 85 (Washington Street).	Project report unavailable to staff	n/a	n/a	n/a	n/a	Minor widening Signal upgrade	n/a	n/a	Victoria now works in Bridge Division. Muazzez Reardon (x8437) has her projects. She works Mondays, Tuesdays, and Fridays.
604697	Farm Road	Marlborough	3	25% Submitted		Reconstruct Farm Road from Cook Lane to Route 20 (Boston Post Road, East).	Project report unavailable to staff	n/a	n/a	n/a	n/a	Reconstruction New sidewalks	n/a	n/a	
604916	Pleasant Street/Morse Street	Norwood	5	25% Submitted		Improve the intersection of Pleasant Street and Morse Street.	Project report unavailable to staff	n/a	n/a	n/a	n/a	Actuated traffic signals, exclusive pedestrian phase, and safety improvements	n/a	n/a	
602261	Route 1A (Main Street)	Walpole	5	25% Submitted		Reconstruct Route 1A (Main Street) from Front Street to the Norfolk town line, and replace the Route 1A Bridge (W-3-24).	Project report unavailable to staff	n/a	n/a	n/a	n/a	Intersection improvements Roadway reconstruction	n/a	n/a	
602593	Union Street	Braintree	4	75% Submitted		Reconstruct Union Street from the Route 3 rotary to Commercial Street.	Project report unavailable to staff	n/a	n/a	n/a	n/a	New traffic signal system Sidewalks/ramps Signs/pavement markings	n/a	n/a	
602493	Pulaski Boulevard, Phase 1	Bellingham	3	75% Submitted	William Chi (7802)	Reconstruct Pulaski Boulevard from Orchard Street to the Franklin town line, realign the Crooks Corner traffic signals, and install new traffic signals at warranted intersections. This project includes work on the intersection of Wrentham Road and Paine Street.	The purpose of this project is to improve traffic safety and operations for motorists and pedestrians. The proposed improvements for Pulaski Boulevard include widening the roadway, rehabilitating the pavement, improving the signals, and providing pedestrian safety improvements. This project includes the intersection of Wrentham Road and Paine Street for a total project length of 2.2 miles.	n/a	n/a	Multiple locations EPDO = 36	1998-2000 No collision diagram	Widening, pedestrian safety improvements, and improved signal timing.			Called Dec. 5. 100% design submitted.
602310	Collins Street	Danvers	4	75% Submitted	William Chi (7802)	Reconstruct Collins Street from Sylvan Street to the intersection of Holten and Centre Streets.	The unsignalized intersection is subject to poor traffic operations on the side street, with queues and delays. Crashes at the intersection are mainly cross-movement (angle collisions). The proposed fully actuated traffic control signal and geometric changes would improve safety and traffic operations.	No	No	Single locations EPDO = 8 Fatal = 0 Injury = 1 PDO = 3	2001-2003 No collision diagram	Roadway widening, sidewalks, curbing, new traffic signals, signage, and pavement markings	12/9/2008	Yes	Called Dec. 5. Project at 75% design and the District is reviewing it. Received FDR on December 9.

APPENDIX B

Project Crash Information

TABLE B-1
Trapelo Road and Belmont Street Corridor Improvements:
2003–2005 Crash Data Used in the Project's Functional Design Report

Intersection with Trapelo Road	Crash Total	Crash Rate[16]	Exceeds MassDOT Average	Collision Diagram
Waverly Oaks Roads	10	0.34	No	No
Mill Street	27	0.70	No	Yes
Pleasant Street	25	0.69	Yes	No
Moraine Street	18	0.62	No	Yes
Lexington Street/Thayer Street	19	0.57	No	No
Church Street	8	0.35	No	Yes
Waverley Street/White Street	10	0.41	No	No
Beech Street	4	0.23	No	No
Slade Street/Harriet Street	5	0.26	No	No
Common Street/Cushing Street	16	0.59	No	No
Belmont Street	9	0.31	No	Yes
School Street	16	0.53	No	Yes
Grove Street/Arlington Street	13	0.45	No	No
Total study intersections (2003–2005)	**180**			
Total for corridor (2004–2006)	**317**			

TABLE B-2
Route 16 Traffic Signal Improvements:
2001–2003 Crash Data Used in the Project's Functional Design Report

Intersection with Route 16	Crash Total	Crash Rate[17]	Exceed MassDOT Average	Collision Diagram
Medway Street	39	1.21	Yes	Yes
Cedar Street	27	1.00	Yes	Yes
Beach Street	25	0.61	No	No
Winter Street	18	0.46	No	No
School Street	19	0.57	No	No
Central Street	8	0.38	No	No
South Main Street	10	1.47	Yes	Yes
Total study intersections (2001–2003)	**146**			
Total for corridor (2004–2006)	**142**			

[16] Crash Rate is measured in crashes per million entering vehicles (MEV)
[17] Ibid.

TABLE B-3
Route 139 (Plain Street) Corridor Improvement Study:
2001–2003 Crash Data Used in the Project's Functional Design Report

Intersection with Route 139	Crash Total	Crash Rate[17]	Exceed MassDOT Average	Collision Diagram
School Street	15	0.34	No	No
Village Street	3	0.07	No	No
Enterprise Drive	17	0.59	No	No
Furnace Street	18	0.84	No	No
Total study intersections (2001–2003)	**53**			
Total for corridor (2004–2006)	**116**			

[17] Ibid.

APPENDIX C

Crash Diagrams

1. Trapelo Road and Belmont Street Corridor Improvements, Belmont
2. Route 16 Traffic Signal Improvements, Milford
3. Route 53 (Washington Street)/Middle Street, Weymouth
4. Reconstruction of Temple Street, Somerville
5. Central Avenue Rehabilitation Project, Milton

1. Trapelo Road and Belmont Street Corridor Improvements, Belmont

COLLISION DIAGRAM

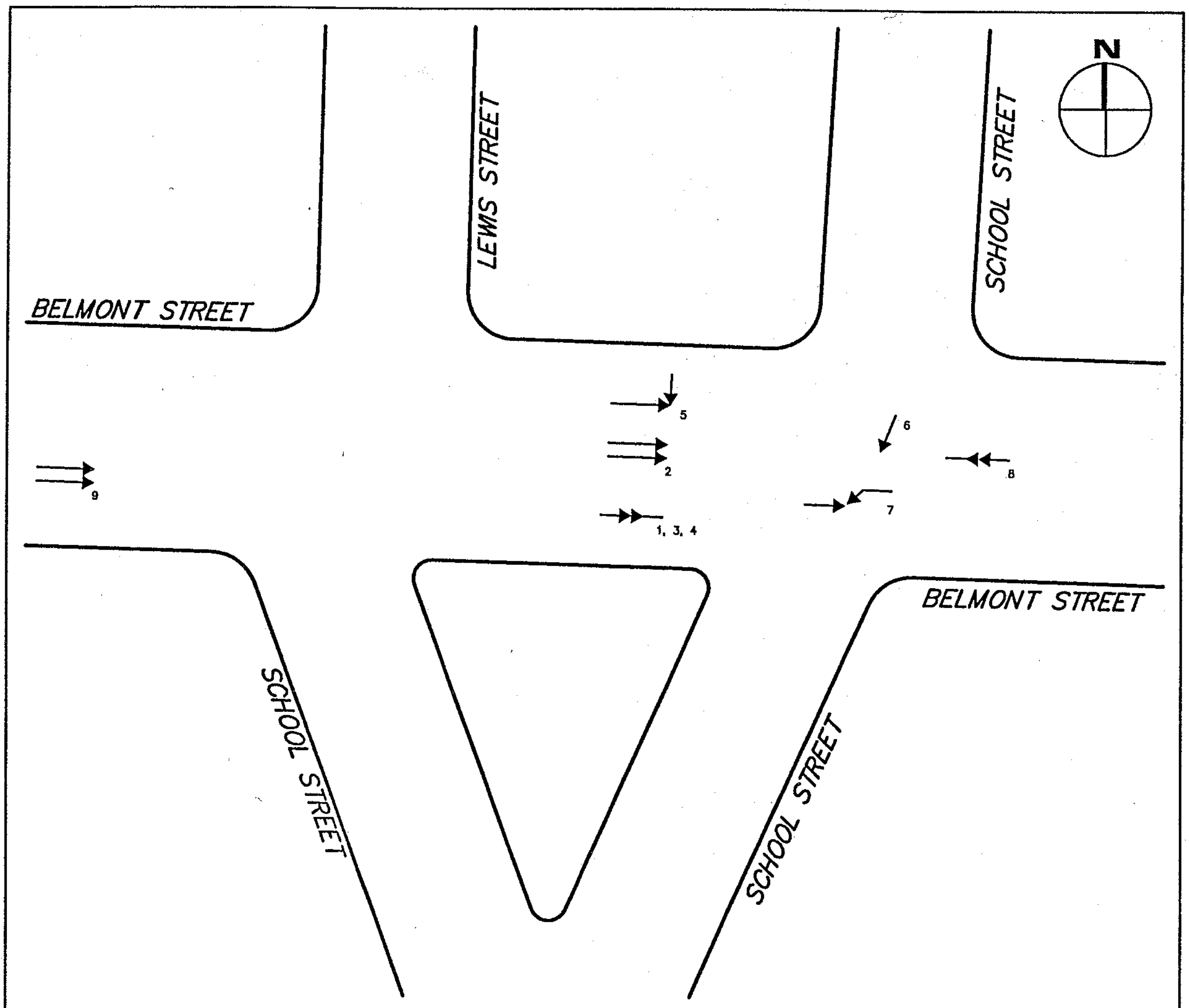
PROJECT: TRAPELO ROAD, BELMONT

LOCATION: BELMONT STREET AT SCHOOL STREET

JOB NUMBER: 2.8172.02

DATE: 08/29/06

BY: JML



SYMBOLS

- ANGLE
- BACKING
- FIXED OBJECT
- HEAD ON
- OUT OF CONTROL
- PEDESTRIAN
- REAR END
- SIDE SWIPE
- TURNING MOVE
- CHANGE LANE
- FATAL ACCIDENT ●
- INJURY ACCIDENT ○
- VEHICLE
- PEDESTRIAN
- FATALITY F
- PERSONS INJURED I

LIGHT CONDITIONS

1. DAYLIGHT
2. DAWN OR DUSK
3. DARKNESS
4. UNKNOWN

ROAD CONDITIONS

1. DRY
2. WET
3. SNOW OR ICY
4. OTHER

VIOLATIONS

0. NO VIOLATIONS
1. SPEED TOO FAST
2. FAILURE TO YIELD
3. RAN STOP SIGN
4. RAN TRAFFIC SIGNAL
5. FOLLOWING TOO CLOSE
6. IMPROPER PASSING
7. WRONG SIDE OF ROAD
8. IMPROPER TURNING
9. IMPROPER BACKING
10. HAD BEEN DRINKING
11. PEDESTRIAN VIOLATION
12. RECKLESS DRIVING
13. IMPROPER LIGHT OR BRAKES

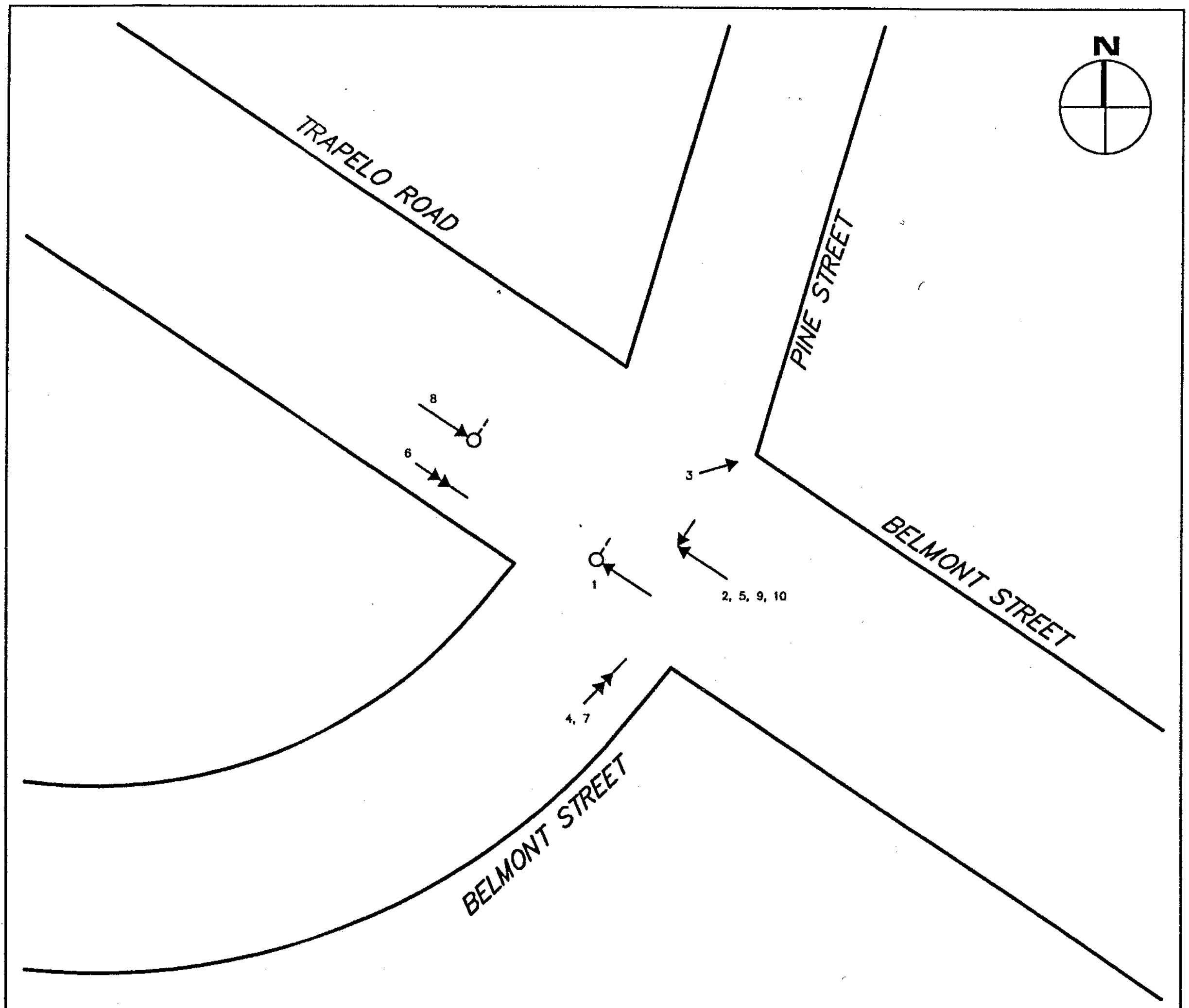
	DATE	TIME	P.D.	F	I	L	R	V		DATE	TIME	P.D.	F	I	L	R	V
1	01/23/03	8:15 PM	YES	0	0	3	1		11								
2	06/11/03	5:23 PM	YES	0	0	1	2		12								
3	09/22/03	7:30 AM	YES	0	1	1	1	5	13								
4	10/31/03	11:58 AM	YES	0	0	1	1	5	14								
5	11/03/03	11:35 AM	YES	0	0	1	1	2	15								
6	06/03/04	7:36 PM	YES	0	1	2	2	0	16								
7	01/17/05	3:30 PM	YES	0	0	1	1		17								
8	10/01/05	9:18 AM	YES	0	0	1	1	5	18								
9	11/21/05	7:52 AM	YES	0	0	1	1	0	19								
10									20								

BSC GROUP

COLLISION DIAGRAM

PROJECT: TRAPELO ROAD, BELMONT   LOCATION: TRAPELO ROAD AT BELMONT STREET / PINE STREET

JOB NUMBER: 2.8172.02   DATE: 08/29/06   BY: JML



SYMBOLS

ANGLE
BACKING
FIXED OBJECT
HEAD ON
OUT OF CONTROL
PEDESTRIAN
REAR END
SIDE SWIPE
TURNING MOVE
CHANGE LANE
FATAL ACCIDENT ●
INJURY ACCIDENT ○
VEHICLE
PEDESTRIAN
FATALITY F
PERSONS INJURED I

LIGHT CONDITIONS

1. DAYLIGHT
2. DAWN OR DUSK
3. DARKNESS
4. UNKNOWN

ROAD CONDITIONS

1. DRY
2. WET
3. SNOW OR ICY
4. OTHER

VIOLATIONS

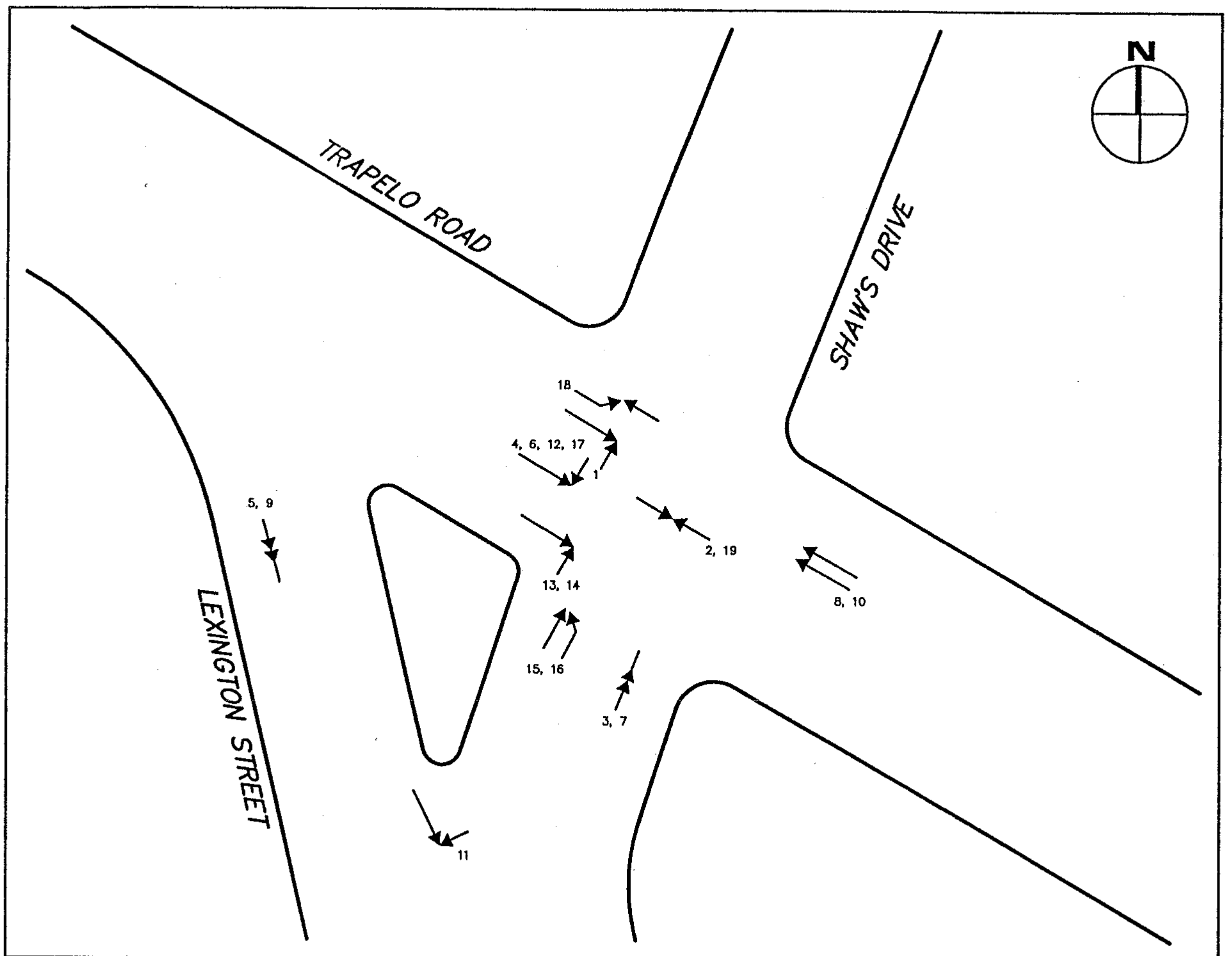
0. NO VIOLATIONS
1. SPEED TOO FAST
2. FAILURE TO YIELD
3. RAN STOP SIGN
4. RAN TRAFFIC SIGNAL
5. FOLLOWING TOO CLOSE
6. IMPROPER PASSING
7. WRONG SIDE OF ROAD
8. IMPROPER TURNING
9. IMPROPER BACKING
10. HAD BEEN DRINKING
11. PEDESTRIAN VIOLATION
12. RECKLESS DRIVING
13. IMPROPER LIGHT OR BRAKES

	DATE	TIME	P.D.	F	I	L	R	V		DATE	TIME	P.D.	F	I	L	R	V
1	03/31/03	4:38 PM	YES	0	1	1	1	8	11								
2	11/01/03	3:40 PM	YES	0	0	1	1	2	12								
3	01/23/04	10:30 AM	YES	0	0	1	1	0	13								
4	04/07/04	3:57 PM	YES	0	0	1	1	5	14								
5	06/18/04	11:13 AM	YES	0	0	1	2	8	15								
6	08/03/04	8:30 PM	YES	0	0	3	1		16								
7	08/29/04	3:00 PM	YES	0	0	1	1		17								
8	03/15/05	7:53 PM	NO	0	1	1	1	2	18								
9	09/05/05	11:36 AM	YES	0	1	1	1	2	19								
10	10/13/05	5:17 PM	YES	0	1	2	2	0	20								

BSC GROUP

COLLISION DIAGRAM

PROJECT: TRAPELO ROAD, BELMONT
LOCATION: TRAPELO ROAD AT LEXINGTON STREET
JOB NUMBER: 2.8172.02
DATE: 08/29/06
BY: JML



SYMBOLS

ANGLE
BACKING
FIXED OBJECT
HEAD ON
OUT OF CONTROL
PEDESTRIAN
REAR END
SIDE SWIPE
TURNING MOVE
CHANGE LANE
FATAL ACCIDENT ●
INJURY ACCIDENT ○
VEHICLE
PEDESTRIAN
FATALITY F
PERSONS INJURED I

LIGHT CONDITIONS

1. DAYLIGHT
2. DAWN OR DUSK
3. DARKNESS
4. UNKNOWN

ROAD CONDITIONS

1. DRY
2. WET
3. SNOW OR ICY
4. OTHER

VIOLATIONS

0. NO VIOLATIONS
1. SPEED TOO FAST
2. FAILURE TO YIELD
3. RAN STOP SIGN
4. RAN TRAFFIC SIGNAL
5. FOLLOWING TOO CLOSE
6. IMPROPER PASSING
7. WRONG SIDE OF ROAD
8. IMPROPER TURNING
9. IMPROPER BACKING
10. HAD BEEN DRINKING
11. PEDESTRIAN VIOLATION
12. RECKLESS DRIVING
13. IMPROPER LIGHT OR BRAKES

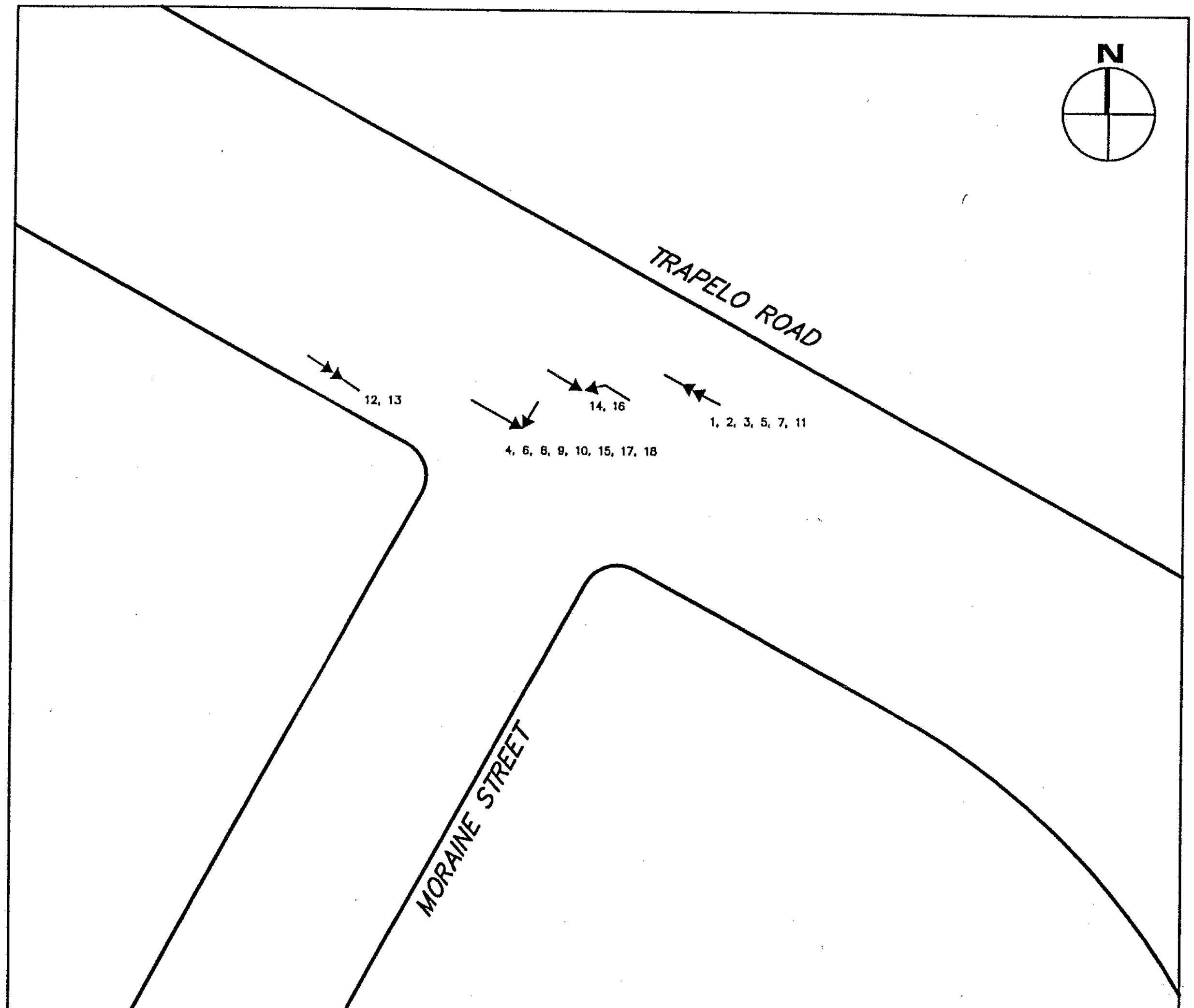
	DATE	TIME	P.D.	F	I	L	R	V		DATE	TIME	P.D.	F	I	L	R	V
1	01/09/03	7:00 PM	YES	0	0	3	2	2	15	04/22/05	3:34 PM	YES	0	0	1	1	0
2	04/11/03	11:20 PM	YES	0	0	3	2	4	16	05/05/05	3:25 PM	YES	0	0	1	1	
3	05/20/03	3:50 PM	YES	0	0	1	1	5	17	10/08/05	6:00 PM	YES	0	0	1	2	0
4	09/13/03	12:20 PM	YES	0	0	1	1	4	18	11/04/05	3:49 PM	YES	0	0	1	1	2
5	09/25/03	5:30 PM	YES	0	0	1	1	2	19	11/15/05	6:35 PM	YES	0	1	1	2	0
6	11/01/03	12:00 PM	YES	0	0	1	1	0	20								
7	12/08/03	7:49 AM	YES	0	0	1	3	0	21								
8	12/10/03	6:05 PM	YES	0	0	1	1	0	22								
9	08/26/04	3:43 PM	YES	0	1	1	1	5	23								
10	09/28/04	2:10 PM	YES	0	0	1	1		24								
11	11/01/04	2:59 PM	YES	0	0	1	1	0	25								
12	11/03/04	8:49 PM	YES	0	0	3	1	0	26								
13	12/19/04	8:45 AM	YES	0	0	1	4	4	27								
14	12/26/04	4:54 PM	YES	0	1	3	3	4	28								

BSC GROUP

COLLISION DIAGRAM

PROJECT: TRAPELO ROAD, BELMONT   LOCATION: TRAPELO ROAD AT MORAINE STREET

JOB NUMBER: 2.8172.02   DATE: 08/29/06   BY: JML



SYMBOLS

ANGLE
BACKING
FIXED OBJECT
HEAD ON
OUT OF CONTROL
PEDESTRIAN
REAR END
SIDE SWIPE
TURNING MOVE
CHANGE LANE
FATAL ACCIDENT ●
INJURY ACCIDENT ○
VEHICLE
PEDESTRIAN
FATALITY F
PERSONS INJURED I

LIGHT CONDITIONS

1. DAYLIGHT
2. DAWN OR DUSK
3. DARKNESS
4. UNKNOWN

ROAD CONDITIONS

1. DRY
2. WET
3. SNOW OR ICY
4. OTHER

VIOLATIONS

0. NO VIOLATIONS
1. SPEED TOO FAST
2. FAILURE TO YIELD
3. RAN STOP SIGN
4. RAN TRAFFIC SIGNAL
5. FOLLOWING TOO CLOSE
6. IMPROPER PASSING
7. WRONG SIDE OF ROAD
8. IMPROPER TURNING
9. IMPROPER BACKING
10. HAD BEEN DRINKING
11. PEDESTRIAN VIOLATION
12. RECKLESS DRIVING
13. IMPROPER LIGHT OR BRAKES

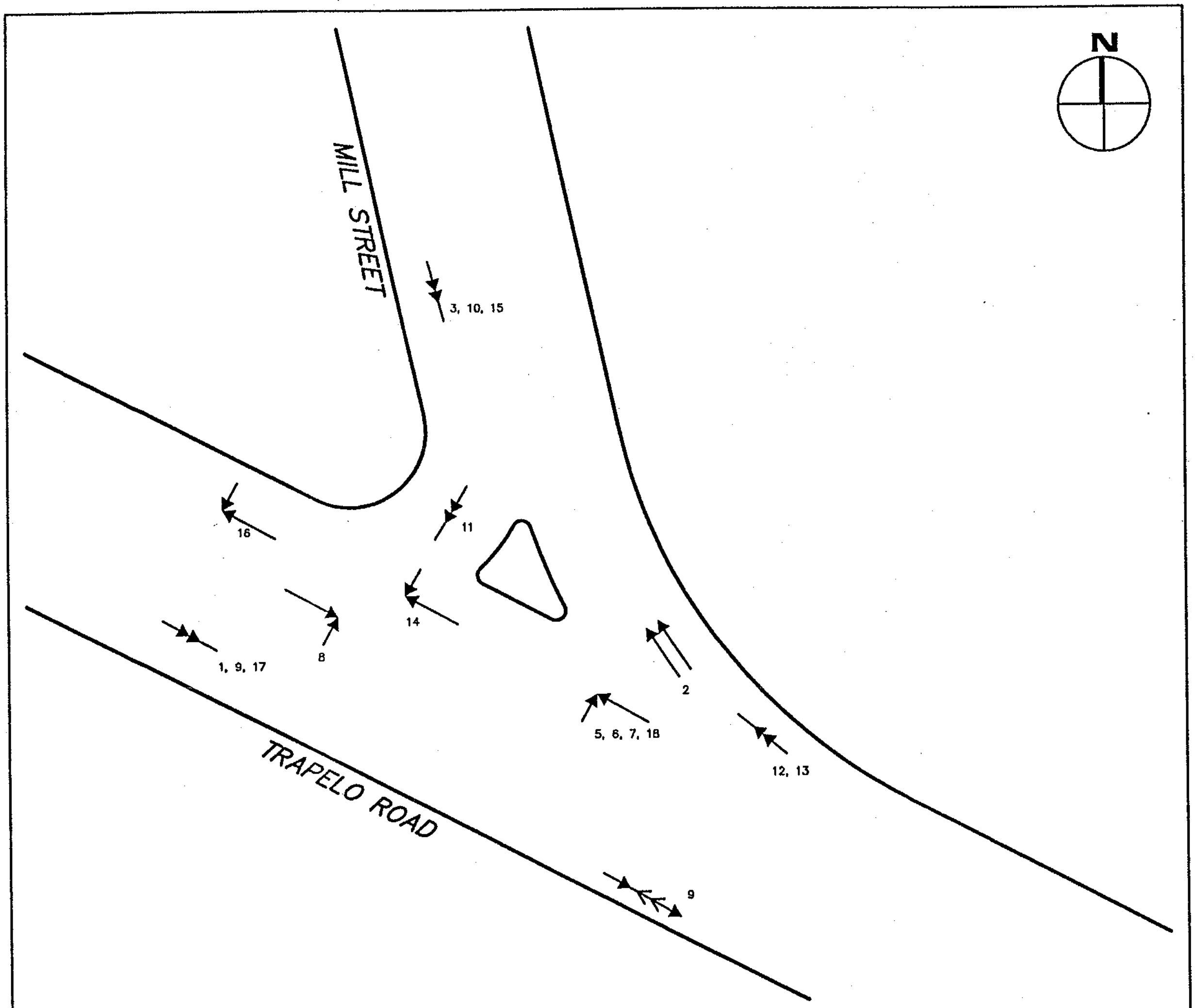
	DATE	TIME	P.D.	F	I	L	R	V		DATE	TIME	P.D.	F	I	L	R	V
1	04/24/03	10:43 PM	YES	0	0	3	1	5	11	12/19/04	1:05 PM	YES	0	0	1	1	0
2	05/17/03	11:20 AM	YES	0	1	1	1		12	04/05/05	3:19 PM	YES	0	0	1	1	5
3	05/30/03	3:25 PM	YES	0	0	1	1	5	13	06/22/05	9:41 AM	YES	0	1	1	2	
4	12/24/03	7:15 AM	YES	0	1	1	1	8	14	07/02/05	3:31 PM	YES	0	0	1	1	8
5	02/11/04	10:28 AM	YES	0	1	1	1	0	15	07/14/05	5:02 PM	YES	0	1			
6	04/15/04	1:05 PM	YES	0	0	1	2	0	16	08/31/05	4:21 PM	YES	0	0	1	2	0
7	05/20/04	2:45 PM	YES	0	1	1	1	5	17	09/22/05	12:45 PM	YES	0	0			8
8	06/14/04	10:45 PM	YES	0	0	3	1	12	18	09/26/05	5:57 PM	YES	0	0			2
9	10/15/04	9:14 AM	YES	0	0	1	2	8	19								
10	11/15/04	3:15 PM	YES	0	0	1	1	2	20								

BSC GROUP

COLLISION DIAGRAM

PROJECT: TRAPELO ROAD, BELMONT   LOCATION: TRAPELO ROAD AT MILL STREET

JOB NUMBER: 2.8172.02   DATE: 08/29/06   BY: JML



SYMBOLS

ANGLE
BACKING
FIXED OBJECT
HEAD ON
OUT OF CONTROL
PEDESTRIAN
REAR END
SIDE SWIPE
TURNING MOVE
CHANGE LANE
FATAL ACCIDENT ●
INJURY ACCIDENT ○
VEHICLE
PEDESTRIAN
FATALITY F
PERSONS INJURED I

LIGHT CONDITIONS

1. DAYLIGHT
2. DAWN OR DUSK
3. DARKNESS
4. UNKNOWN

ROAD CONDITIONS

1. DRY
2. WET
3. SNOW OR ICY
4. OTHER

VIOLATIONS

0. NO VIOLATIONS
1. SPEED TOO FAST
2. FAILURE TO YIELD
3. RAN STOP SIGN
4. RAN TRAFFIC SIGNAL
5. FOLLOWING TOO CLOSE
6. IMPROPER PASSING
7. WRONG SIDE OF ROAD
8. IMPROPER TURNING
9. IMPROPER BACKING
10. HAD BEEN DRINKING
11. PEDESTRIAN VIOLATION
12. RECKLESS DRIVING
13. IMPROPER LIGHT OR BRAKES

	DATE	TIME	P.D.	F	I	L	R	V		DATE	TIME	P.D.	F	I	L	R	V
1	01/21/03	11:40 PM	YES	0	1	3	1	10	11	07/30/04	3:05 PM	YES	0	0	1	1	5
2	04/30/03	10:00 AM	YES	0	0	1	1	0	12	09/21/04	1:08 PM	YES	0	0	1	1	5
3	06/06/03	5:45 PM	YES	0	0	1	1	5	13	09/24/04	5:15 PM	YES	0	0	1	1	0
4	07/02/03	4:07 PM		0	0	1	1		14	09/29/04	2:40 PM	YES	0	0	1	1	4
5	07/29/03	3:30 PM	YES	0	1	1	1	0	15	10/29/04	11:15 AM	YES	0	0	1	1	0
6	08/05/03	9:00 PM	YES	0	2	3	1	2	16	11/16/04	3:37 PM	YES	0	0	1	1	0
7	01/05/04	9:45 PM	YES	0	0	3	2	2	17	02/15/05	11:36 AM	YES	0	0	1	1	
8	01/29/04	1:30 PM	YES	0	0	1	1	6	18	07/14/05	8:58 AM	YES	0	0	1	1	2
9	10/08/04	11:54 AM	YES	0	0	1	1	10	19								
10	06/16/04	3:50 PM	YES	0	0	1	1	5	20								

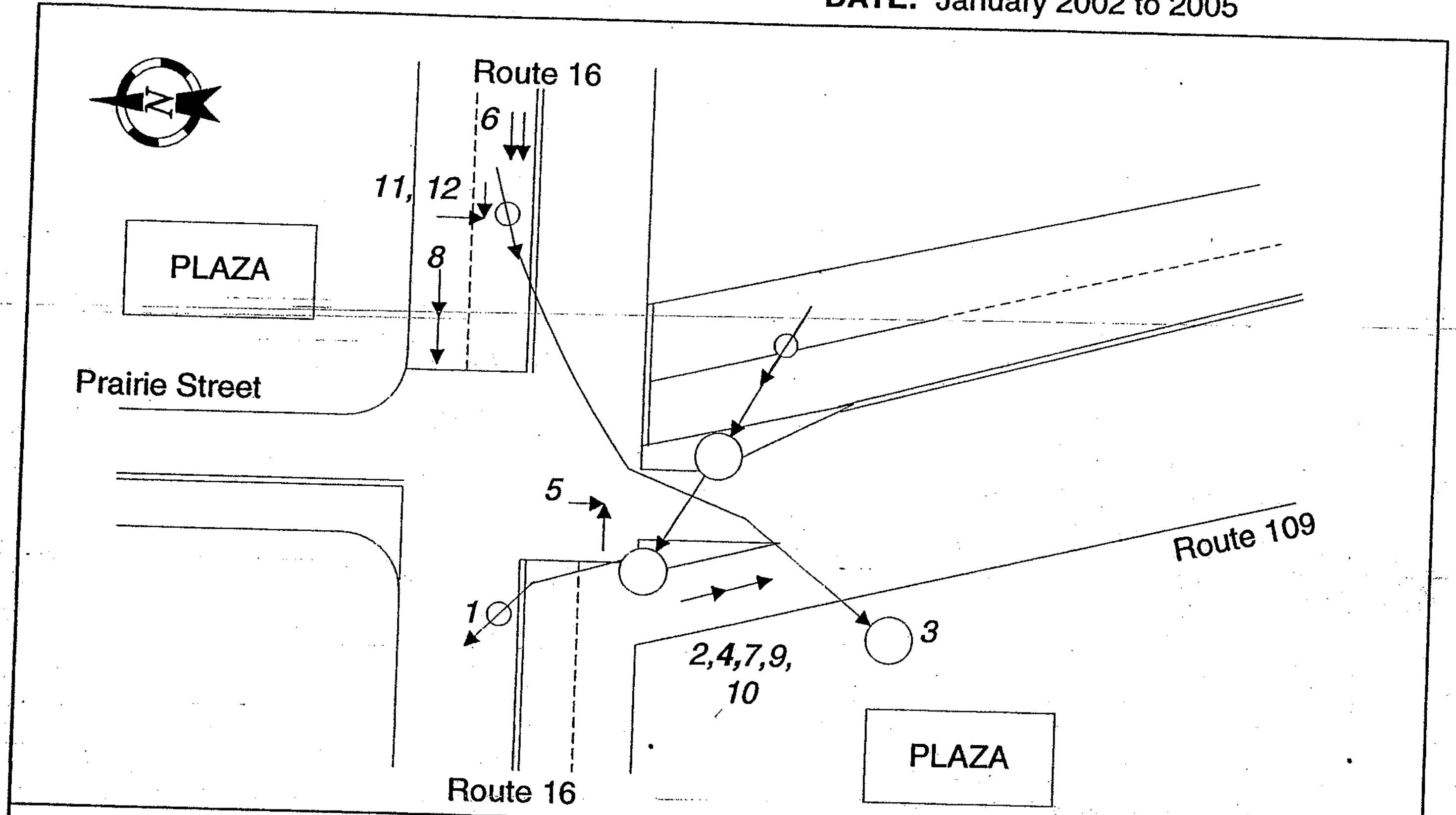
BSC GROUP

2. Route 16 Traffic Signal Improvements, Milford

Figure 8
COLLISION DIAGRAM

PROJECT: FDR - Route 16 (Milford Center)
JOB NUMBER: 811

LOCATION: Route 16 at Route 109
DATE: January 2002 to 2005



SYMBOLS

Angle
Rear End
Backing
Fixed Object
Head On
Out of Control
Pedestrian
Side Swipe
Turning Movement
Change Lane
Fatal F
Injury I
Property Damage Only PD

LIGHT COND.
1. Daylight
2. Dawn/Dusk
3. Darkness
4. Unknown

ROAD COND.
1. Dry
2. Wet
3. Snow/Ice
4. Other

VIOLATIONS
0. No Violations
1. Speed Too Fast
2. Failure To Yield
3. Ran Stop Sign
4. Ran Traffic Signal
5. Following Too Close
6. Improper Passing
7. Wrong Side of Road
8. Improper Turning
9. Improper Backing
10. Ped. Violation
12. Reckless Driving
13. Improper Lights

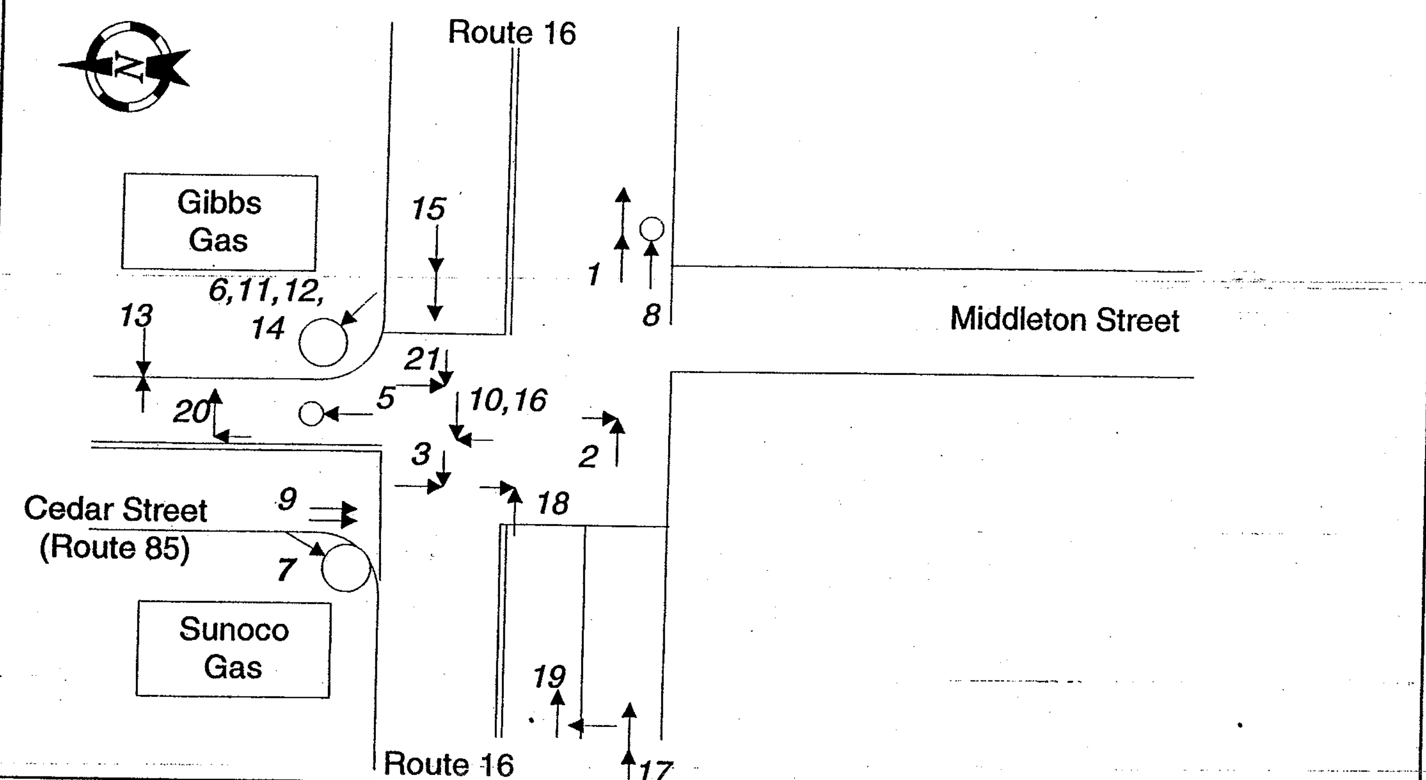
* No Diagram Available ** Under Investigation

	DATE	TIME	DAY	SEV.	L	R	V
1	4/5/2002	300	Fri	PD	*	*	12
2	4/18/2002	1210	Thu	PD	1	1	0
3	4/28/2002	2008	Sun	PD	3	2	0
4	5/6/2002	1603	Mon	I	1	*	0
5	8/16/2002	1331	Fri	PD	1	1	0
6	9/4/2002	1024	Wed	PD	1	1	8
7	9/27/2002	1732	Fri	PD	1	1	0
8	10/9/2002	600	Wed	PD	2	1	5
9	10/29/2002	850	Tue	PD	1	1	0
10	11/23/2002	1202	Sat	PD	1	1	0
11	12/19/2002	2053	Thu	PD	3	1	0
12	9/18/2004	1239	Sat	PD	1	2	0
13							
14							
15							

Figure 9
COLLISION DIAGRAM

PROJECT: FDR - Route 16 (Milford Center)
JOB NUMBER: 811

LOCATION: Route 16 at Route 85
DATE: January 2002 to 2005



SYMBOLS

Angle		Side Swipe	
Rear End		Turning Movement	
Backing		Change Lane	
Fixed Object			
Head On		Fatal	F
Out of Control		Injury	I
Pedestrian		Property Damage Only	PD

LIGHT COND.
1. Daylight
2. Dawn/Dusk
3. Darkness
4. Unknown

ROAD COND.
1. Dry
2. Wet
3. Snow/Ice
4. Other

VIOLATIONS
0. No Violations
1. Speed Too Fast
2. Failure To Yield
3. Ran Stop Sign
4. Ran Traffic Signal
5. Following Too Close
6. Improper Passing
7. Wrong Side of Road
8. Improper Turning
9. Improper Backing
10. Ped. Violation
12. Reckless Driving
13. Improper Lights

* No Diagram Available ** Under Investigation

	DATE	TIME	DAY	SEV.	L	R	V
1	3/27/2002	1045	Wed	PD	1	1	0
2	4/23/2002	1251	Tue	PD	1	1	4
3	4/24/2002	550	Wed	PD	2	1	4
*4	6/2/2002	1350	Sun	I	1	1	5
5	6/7/2002	*	Fri	PD	1	2	0
6	6/16/2002	1520	Sun	PD	1	1	0
7	7/6/2002	1725	Sat	PD	1	1	0
8	8/24/2002	1755	Sat	I	1	1	0
9	9/4/2002	1605	Wed	PD	1	1	8
10	11/13/2002	725	Wed	PD	1	1	2
11	11/19/2002	1438	Tue	PD	1	1	0
12	12/17/2002	1515	Tue	PD	1	1	0
13	12/18/2002	1249	Wed	PD	1	1	0
14	10/9/2003	843	Thu	PD	1	1	0
15	11/10/2003	2058	Mon	PD	1	1	0

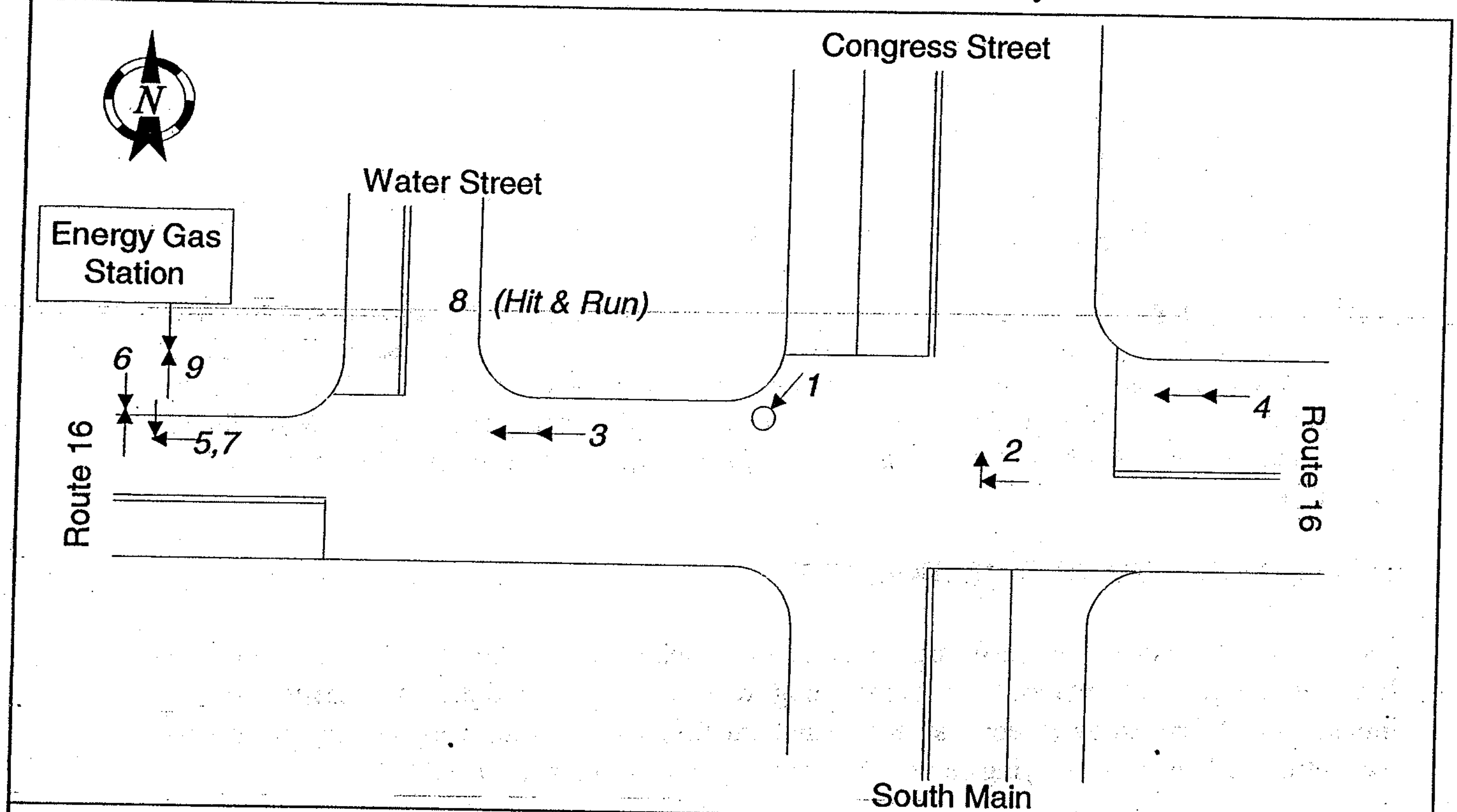
	DATE	TIME	DAY	SEV.	L	R	V
16	1/13/2004	1115	Tue	PD	1	1	0
17	3/3/2004	1040	Wed	PD	1	1	0
18	6/11/2004	2056	Fri	I	1	1	4
19	7/22/2004	943	Thu	PD	1	1	0
20	12/28/2005	855	Wed	PD	1	3	8
21	4/2/2005	1556	Sat	PD	1	1	4
22			Sat				
23			Sat				
24			Sat				
25			Sat				
26			Sat				
27			Sat				
28			Sat				
29			Sat				
30			Sat				

MS Transportation Systems, Inc.

Figure 10
COLLISION DIAGRAM

PROJECT: FDR - Route 16 (Milford Center)
JOB NUMBER: 811

LOCATION: Route 16 at South Main Street
DATE: January 2002 to 2005



SYMBOLS

Angle		Side Swipe	
Rear End		Turning Movement	
Backing		Change Lane	
Fixed Object			
Head On		Fatal	F
Out of Control		Injury	I
Pedestrian		Property Damage Only	PD

LIGHT COND.
1. Daylight
2. Dawn/Dusk
3. Darkness
4. Unknown

ROAD COND.
1. Dry
2. Wet
3. Snow/Ice
4. Other

VIOLATIONS
0. No Violations
1. Speed Too Fast
2. Failure To Yield
3. Ran Stop Sign
4. Ran Traffic Signal
5. Following Too Close
6. Improper Passing
* No Diagram Available
7. Wrong Side of Road
8. Improper Turning
9. Improper Backing
10. Ped. Violation
12. Reckless Driving
13. Improper Lights
14. Revoked Liscense
** Under Investigation

	DATE	TIME	DAY	SEV.	L	R	V
1	3/7/2002	615	Thu	PD	2	1	10
2	6/3/2002	1154	Mon	PD	1	1	14
3	7/22/2002	1643	Mon	PD	1	1	0
4	11/11/2002	1130	Mon	PD	1	1	0
5	11/15/2002	1458	Fri	PD	1	1	0
6	7/29/2003	658	Tue	PD	1	1	8
7	11/28/2003	1927	Fri	PD	3	1	0
8	11/4/2004	2035	Thu	PD	3	1	*
9	1/6/2005	1311	Thu	PD	1	3	0
10			Sat				
11			Sat				
12			Sat				
13			Sat				
14			Sat				
15			Sat				

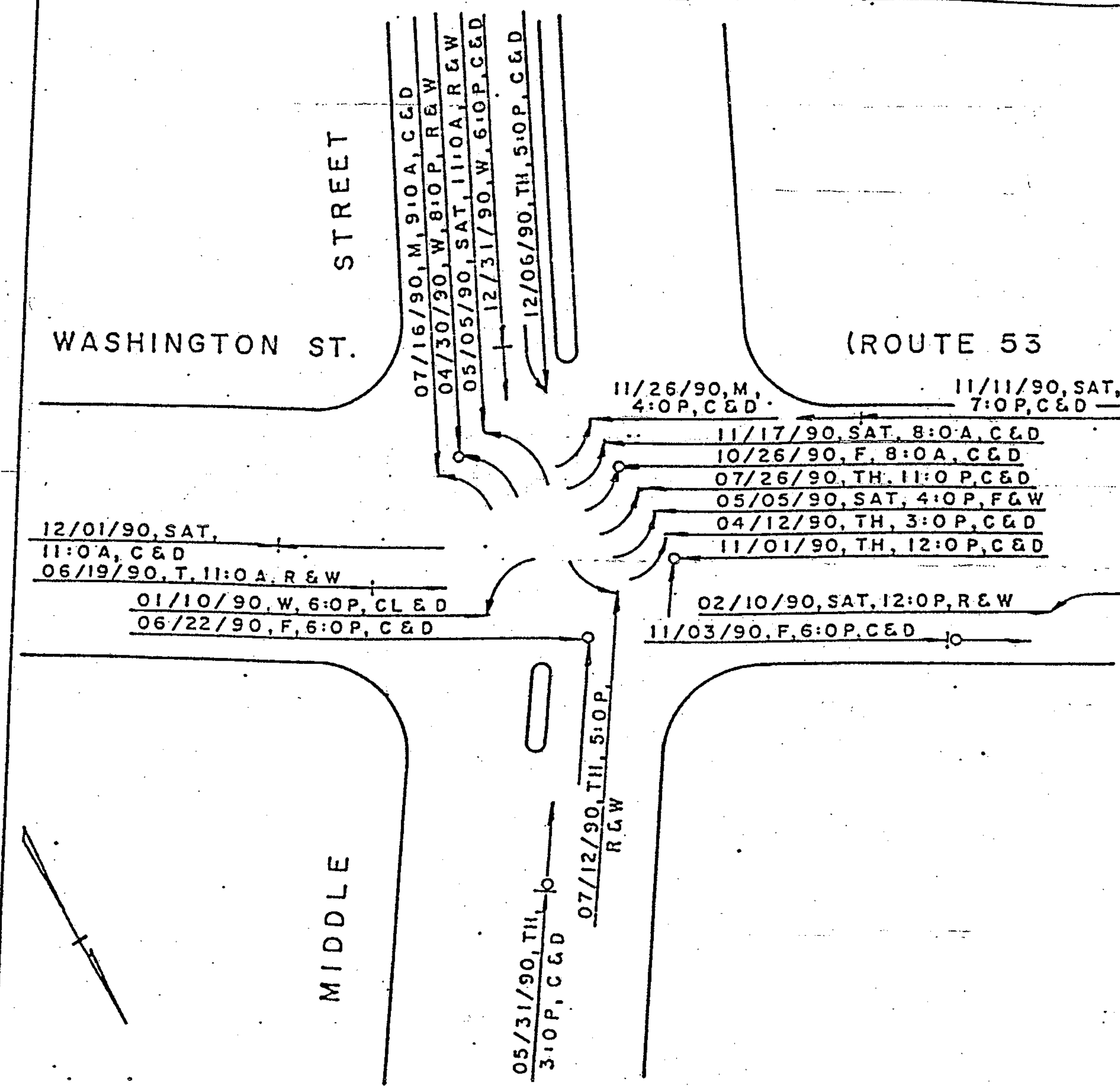
3. Route 53 (Washington Street)/Middle Street, Weymouth

COLLISION DIAGRAM

INTERSECTION WASHINGTON ST. (RTE. 53) AND MIDDLE STREET

PERIOD 1990 FROM JANUARY TO DECEMBER

CITY / TOWN WEYMOUTH PREPARED BY G. I. A.



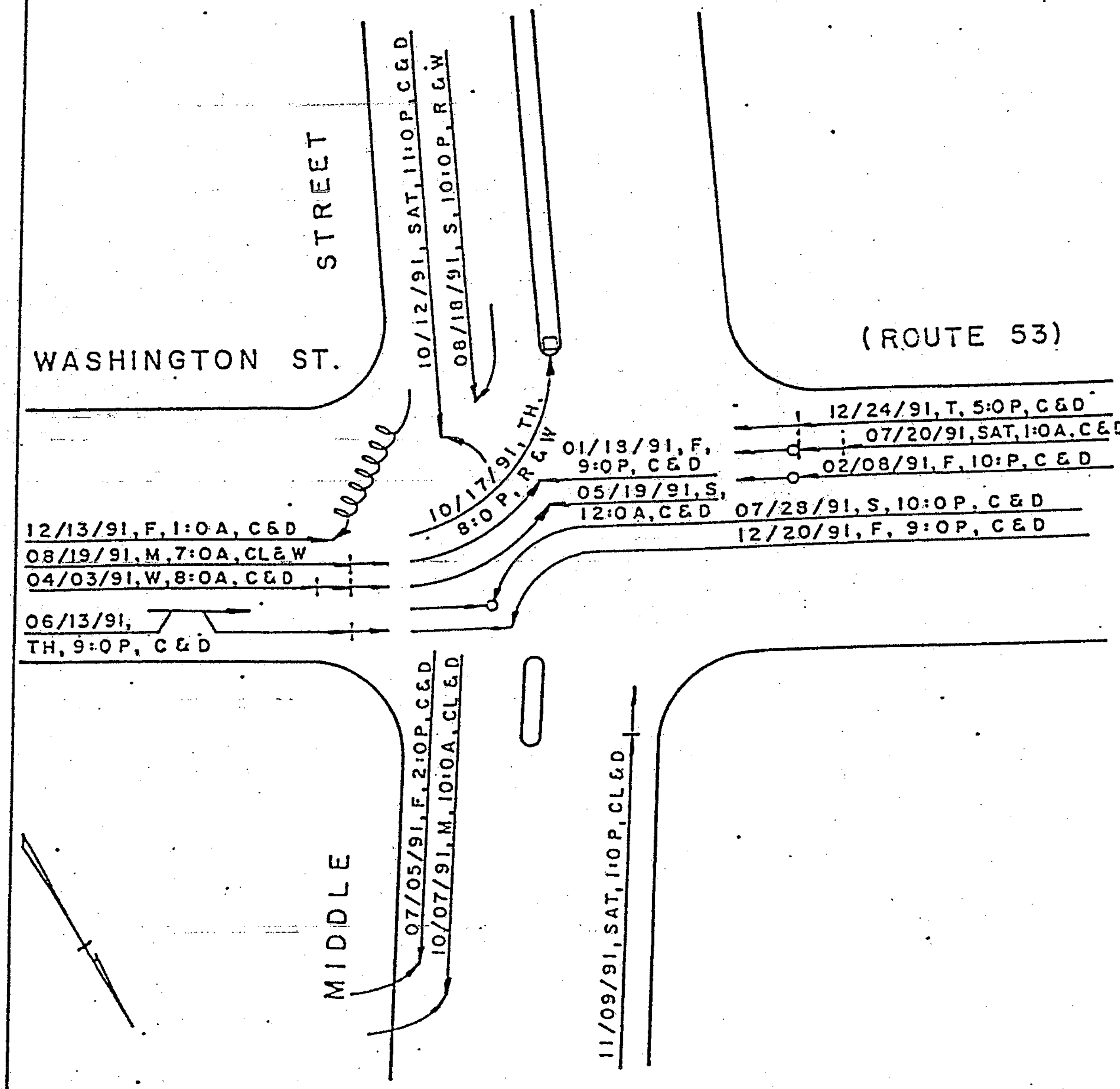
NUMBER OF ACCIDENTS	SYMBOLS	TYPE OF COLLISIONS	SHOW FOR EACH ACCIDENT
PROPERTY DAMAGE ONLY	MOVING VEHICLE	REAR END	1. TIME, DAY, DATE
INJURY OR FATAL	BACKING VEHICLE	HEAD ON	2. WEATHER AND ROAD SURFACE-IF UNUSUAL CONDITION EXISTED
TOTAL ACCIDENTS	NON-INVOLVED VEHICLE	SIDE – SWIPE	3. NITE – IF BETWEEN DUSK AND DAWN
	PEDESTRIAN	OUT OF CONTROL	
	PARKED VEHICLE	LEFT TURN	
	FIXED OBJECT	RIGHT ANGLE	
	FATAL ACCIDENT		
	INJURY ACCIDENT		

COLLISION DIAGRAM

INTERSECTION WASHINGTON ST. (RTE. 53) AND MIDDLE STREET

PERIOD 1991 FROM JANUARY TO DECEMBER

CITY / TOWN WEYMOUTH PREPARED BY G. I. A.



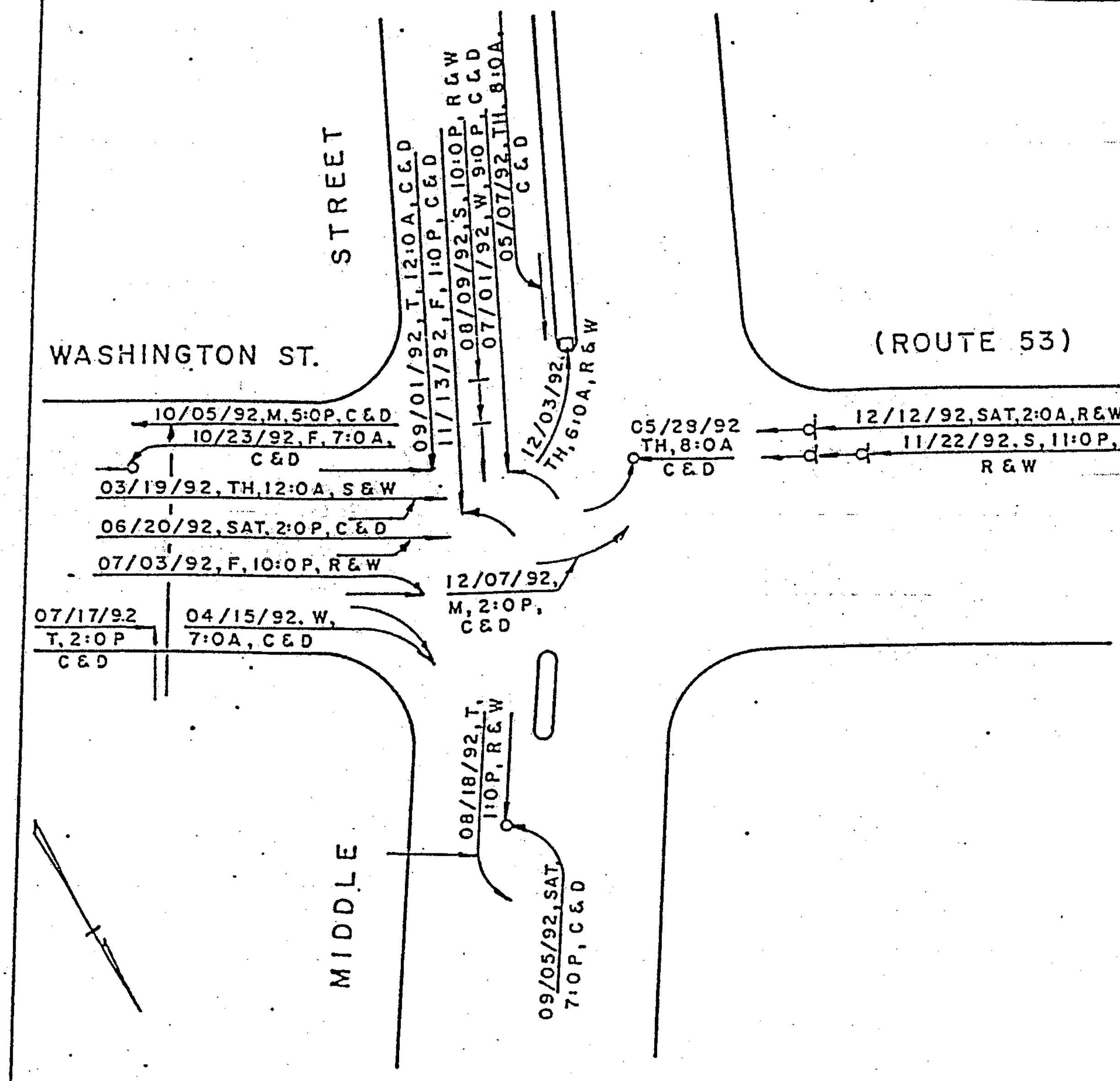
NUMBER OF ACCIDENTS	SYMBOLS	TYPE OF COLLISIONS	SHOW FOR EACH ACCIDENT
PROPERTY DAMAGE ONLY	MOVING VEHICLE	REAR END	1. TIME, DAY, DATE
INJURY OR FATAL	BACKING VEHICLE	HEAD ON	2. WEATHER AND ROAD SURFACE - IF UNUSUAL CONDITION EXISTED
TOTAL ACCIDENTS	NON-INVOLVED VEHICLE	SIDE - SWIPE	3. NITE - IF BETWEEN DUSK AND DOWN
	PEDESTRIAN	OUT OF CONTROL	
	PARKED VEHICLE	LEFT TURN	
	FIXED OBJECT	RIGHT ANGLE	
	FATAL ACCIDENT		
	INJURY ACCIDENT		

COLLISION DIAGRAM

INTERSECTION WASHINGTON ST. (RTE. 53) AND MIDDLE STREET

PERIOD 1992 FROM JANUARY TO DECEMBER

CITY / TOWN WEYMOUTH PREPARED BY G. I. A.

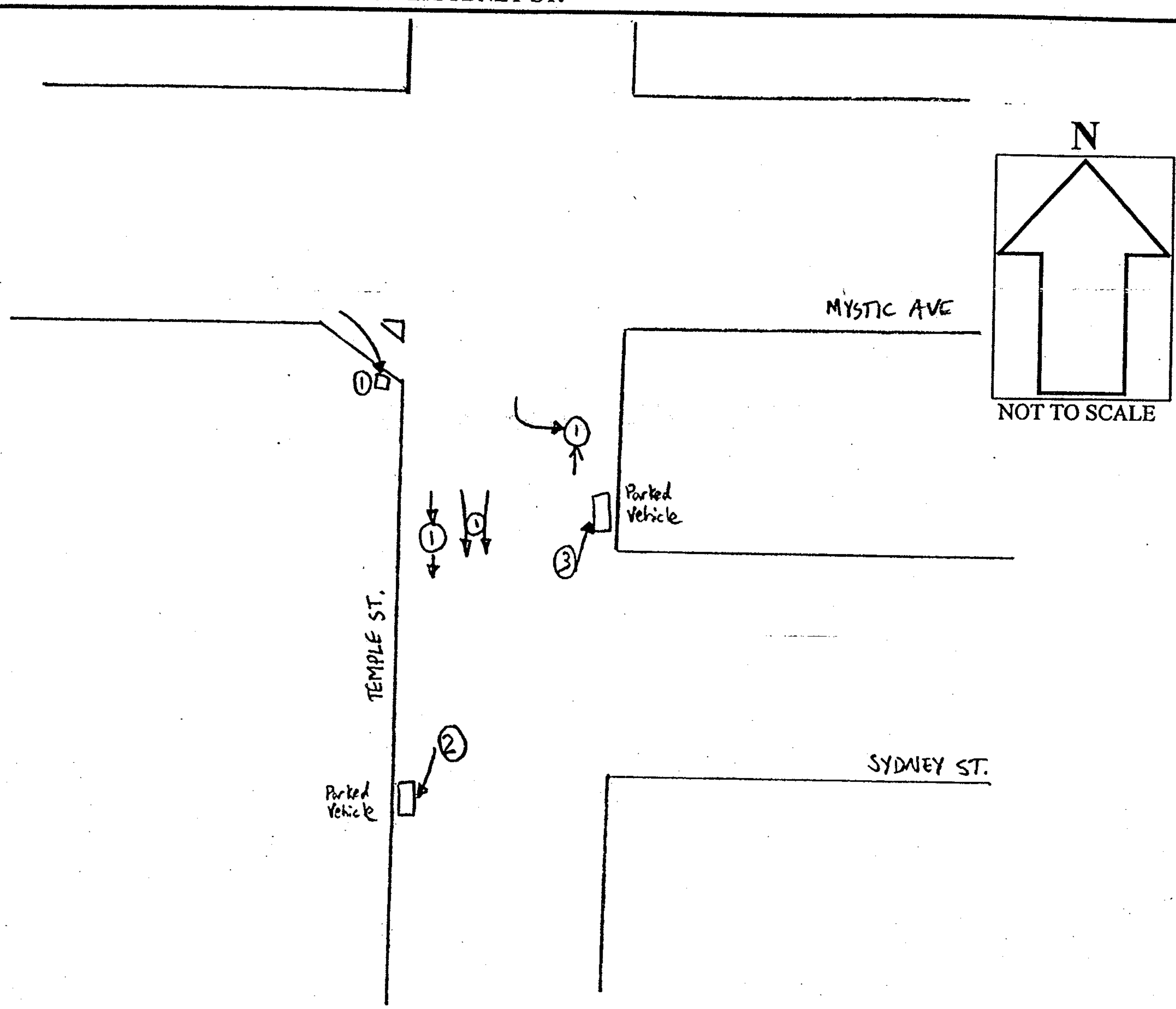


NUMBER OF ACCIDENTS	SYMBOLS	TYPE OF COLLISIONS	SHOW FOR EACH ACCIDENT
PROPERTY DAMAGE ONLY	MOVING VEHICLE	REAR END	1. TIME, DAY, DATE
INJURY OR FATAL	BACKING VEHICLE	HEAD ON	2. WEATHER AND ROAD SURFACE-IF UNUSUAL CONDITION EXISTED
TOTAL ACCIDENTS	NON-INVOLVED VEHICLE	SIDE - SWIPE	3. NITE - IF BETWEEN DUSK AND DAWN
	PEDESTRIAN	OUT OF CONTROL	
	PARKED VEHICLE	LEFT TURN	
	FIXED OBJECT	RIGHT ANGLE	
	FATAL ACCIDENT		
	INJURY ACCIDENT		

4. Reconstruction of Temple Street, Somerville

ACCIDENT DIAGRAM

CITY NAME:	SOMERVILLE
MAJOR STREET:	TEMPLE ST.
MINOR STREET:	MYSTIC AVE./SYDNEY ST.



Head-on Accident

Right Angle Broadside Accident

Turning Movement Broadside Accident

Rear End Accident

Overtaking Sideswipe Accident

Head-on Sideswipe Accident

Hit Object Accident

Vehicle Rolled

Vehicle Out of Control

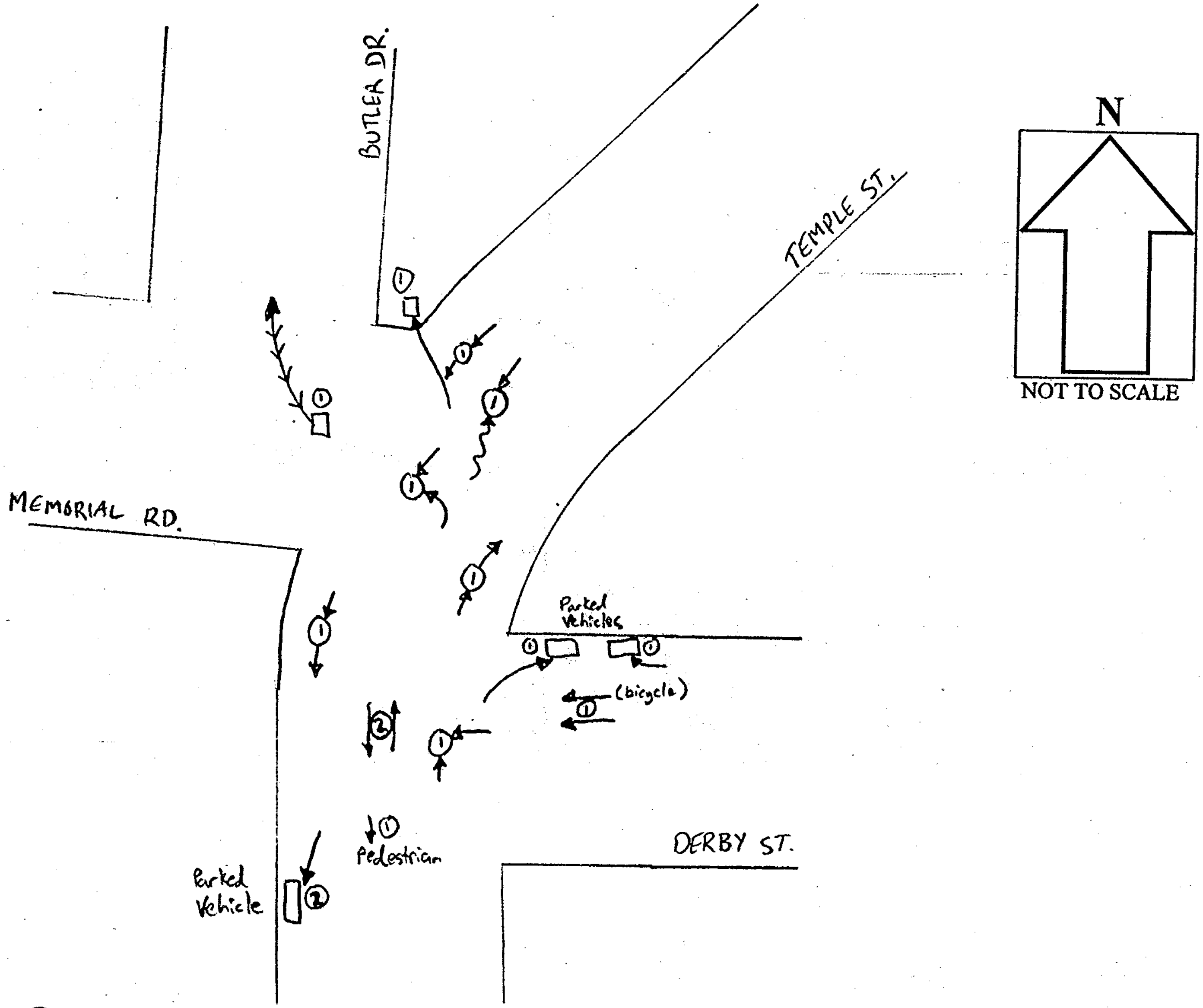
Vehicle Backing-up or Rolling Backwards

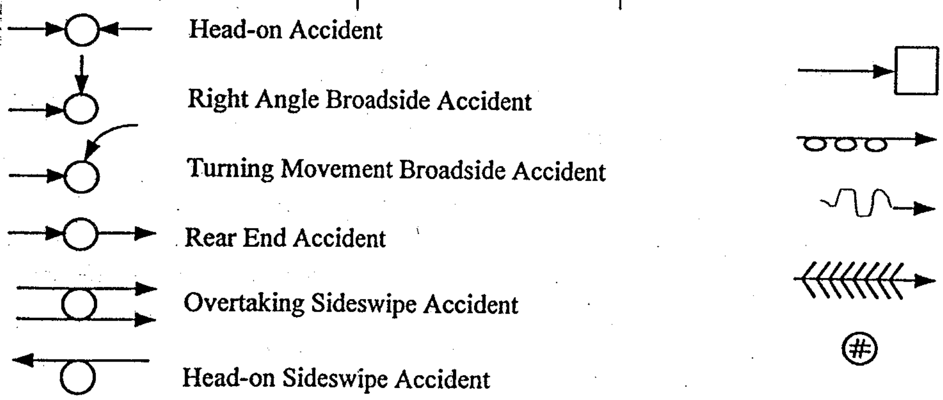
Number of Similar Accidents at Same Location

Guertin & Associates
57032.00\temple\reports\traffic1

ACCIDENT DIAGRAM

CITY NAME:	SOMERVILLE
MAJOR STREET:	TEMPLE ST.
MINOR STREET:	MEMORIAL RD./BUTLER DR./DERBY ST.





Head-on Accident

Right Angle Broadside Accident

Turning Movement Broadside Accident

Rear End Accident

Overtaking Sideswipe Accident

Head-on Sideswipe Accident

Hit Object Accident

Vehicle Rolled

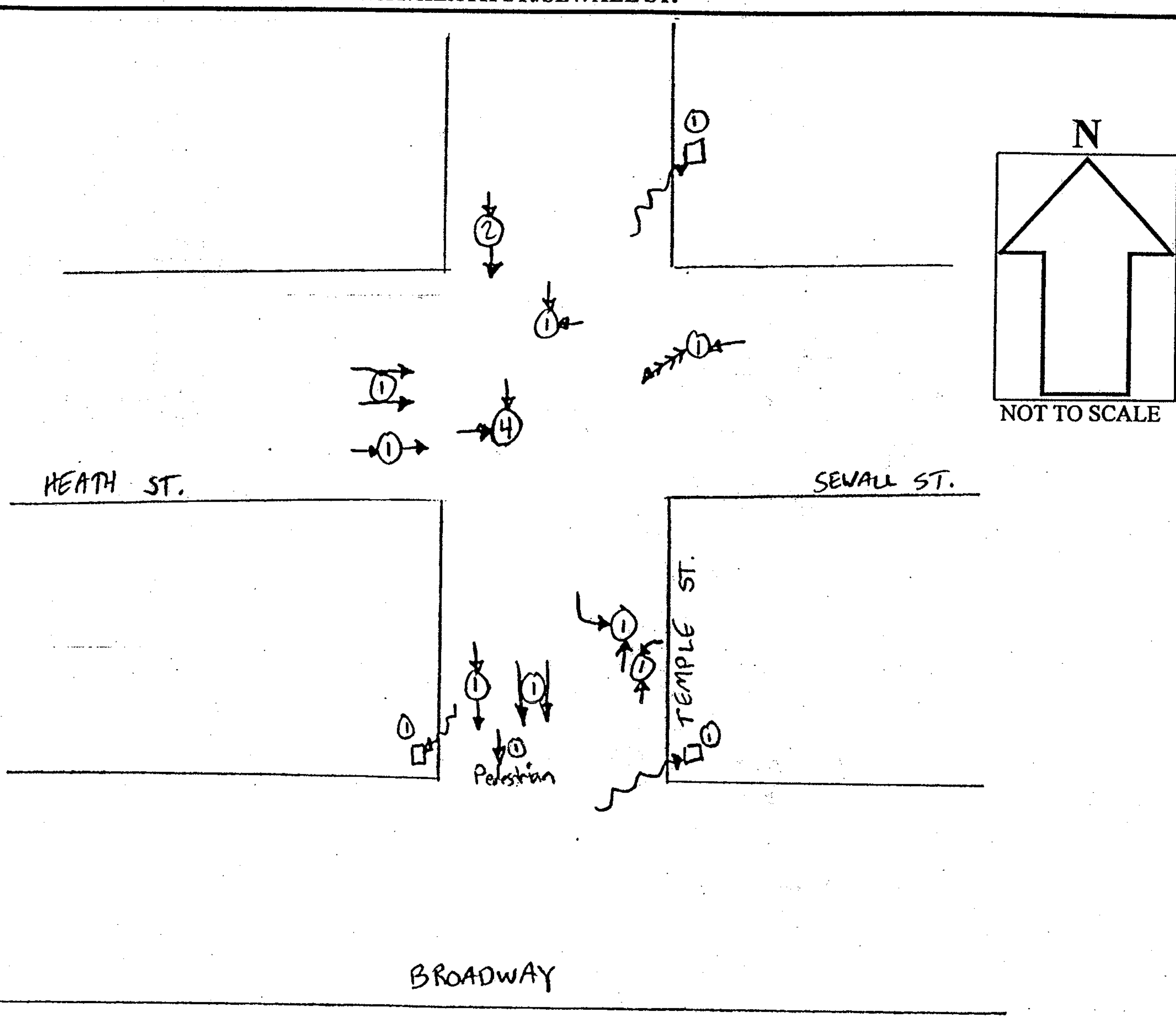
Vehicle Out of Control

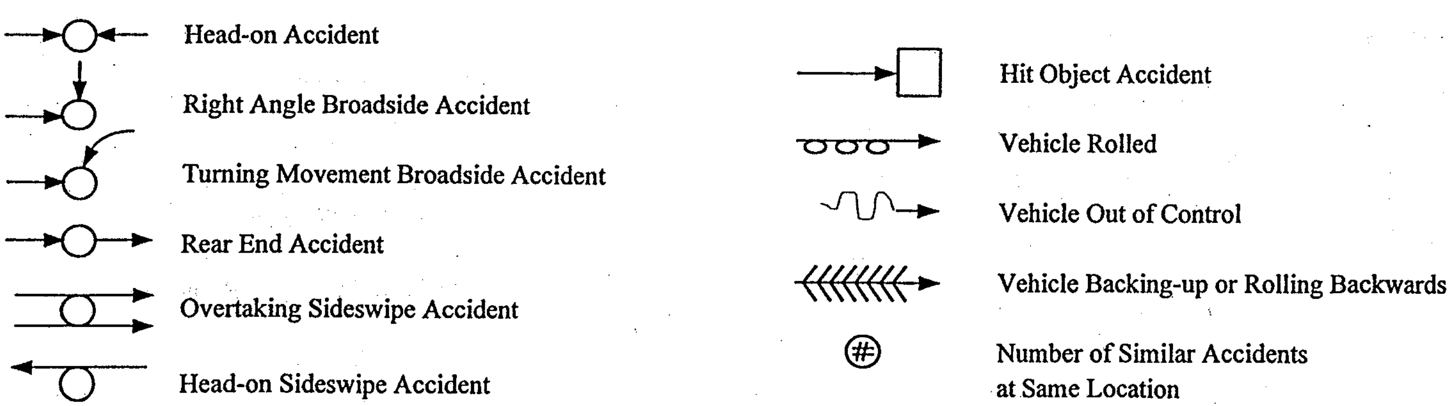
Vehicle Backing-up or Rolling Backwards

Number of Similar Accidents at Same Location

ACCIDENT DIAGRAM

CITY NAME:	SOMERVILLE
MAJOR STREET:	TEMPLE ST.
MINOR STREET:	BROADWAY/HEATH ST./SEWALL ST.





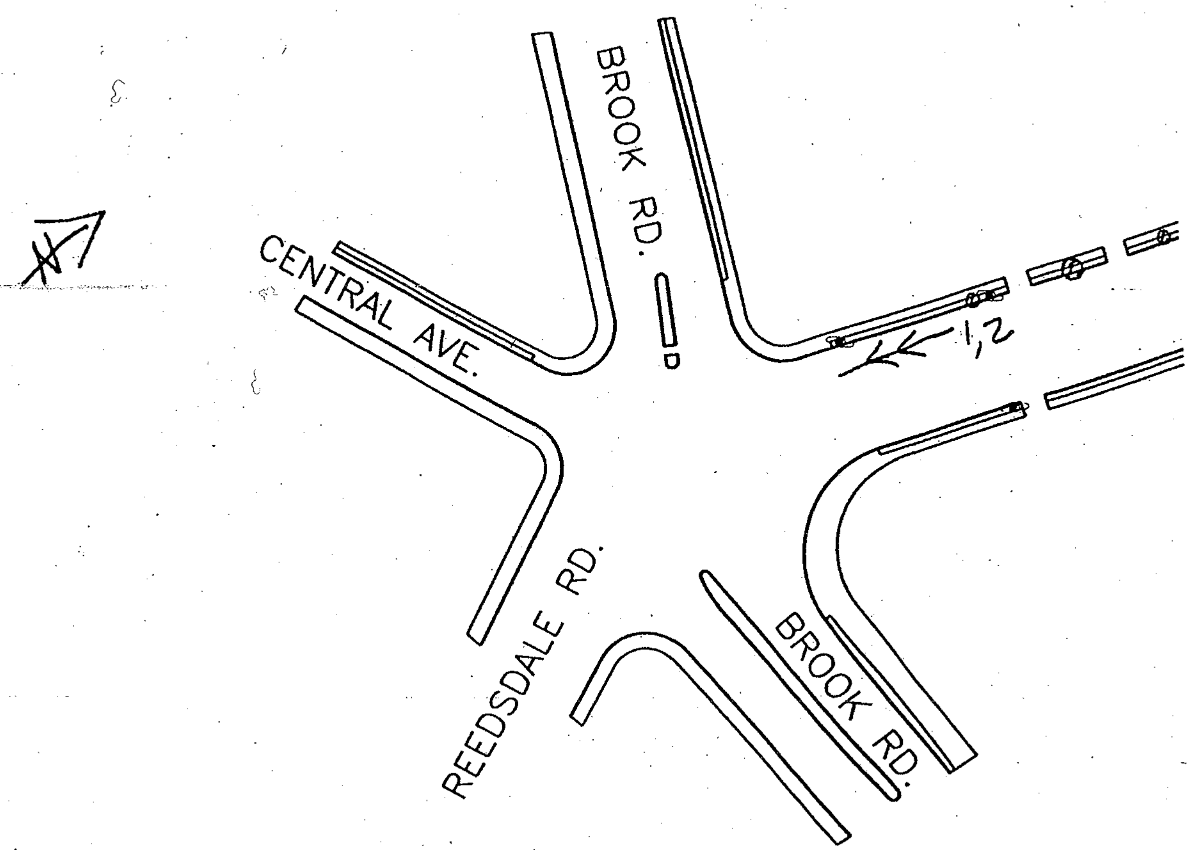
Guertin & Associates
57032.00\temple\reports\traffic1

5. Central Avenue Rehabilitation Project, Milton

COLLISION DIAGRAM

PROJECT NEX-2003028.00 LOCATION CENTRAL AVE, BROOK ROAD, REEDSDALE RD.

JOB NO. Central Ave Rehabilitation DATE 8/14/03 BY LDS



SYMBOLS

ANGLE
BACKING
FIXED OBJECT
HEAD ON
OUT OF CONTROL
PEDESTRIAN
REAR END
SIDE SWIPE
TURNING MOVE
CHANGE LANE
FATAL ACCIDENT ●
INJURY ACCIDENT ○
VEHICLE
PEDESTRIAN
PERSONS KILLED K
PERSONS INJURED I

LIGHT CONDITIONS

1. DAYLIGHT
2. DAWN OR DUSK
3. DARKNESS
4. UNKNOWN

ROAD CONDITIONS

1. DRY
2. WET
3. SNOW OR ICY
4. OTHER

VIOLATIONS

0. NO VIOLATIONS
1. SPEED TOO FAST
2. FAILURE TO YIELD
3. RAN STOP SIGN
4. RAN TRAFFIC SIGNAL
5. FOLLOWING TOO CLOSE
6. IMPROPER PASSING
7. WRONG SIDE OF ROAD
8. IMPROPER TURNING
9. IMPROPER BACKING
10. HAD BEEN DRINKING
11. PEDESTRIAN VIOLATION
12. RECKLESS DRIVING
13. IMPROPER LIGHT OR BRAK

	DATE	TIME	P.D.	K	I	L	R	V		DATE	TIME	P.D.	K	I	L	R
1	6/01/01	8:57AM	✓	0	0	1	1	0	11							
2	6/07/01	10:48AM	✓	0	1	4	1	0	12							
3									13							
4									14							
5									15							
6									16							
7									17							
8									18							
9									19							
10									20							

BASED ON REPORTS FILED WITH TOWN OF MILTON POLICE DEPT.